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Characteristic and Development Report SA3581/MC4196 Lightning Arrestor Connector (LAC)

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Abstract

This report describes the design, development, manufacturing processes, acceptance equipment, test results, and conclusions for the SA3581/MC4196 LAC program. Four development groups (Identified as Groups 1 through 3 and a Proof of Development Build) provided the evaluation criteria for the PPI/TMS production units.

Acknowledgments

The authors would like to acknowledge the contributions of the SNL staff in general, the SNL W89 Systems Group, and the staff at AMphenol-BCO. Thanks also to Betty Tolman of Technical Communications at Sandia.

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Acronyms

BCO	Bendix Connector Operations
CER/DTER	Complete Engineering Release/Drawing Transfer Engineering Release
DCWV	direct current voltage withstanding
DEA	diethanolamine
DOE	Department of Energy
DS	development specification
DWV	dielectric withstanding voltage
EMP	electromagnetic pulse
EMR	electromagnetic radiation
ESD	electrostatic discharge
FRB	fast rise-time breakdown
GMS	glass microspheres
HVA	high velocity accelerator
ICR	inductance/capacitance resistance
IR	insulation resistance
ITI	incoming test and inspection
KCD	Kansas City Division
LAC	lightning arrestor connector
LJT	long junior trilock
MMSC	Martin Marietta Specialty Components, Inc.
OI	operating instruction
PP	Pinellas Plant
PPI	process prove-in
QER	Qualification Engineering Release
QS	quality survey
SA	standard assembly
S/N	serial number
SRAM	short-range attack missile
TMS	tool made sample
S/N MMSC	Serial Number Martin Marietta Specialty Components, Inc.
S/N BCO	Serial Number Bendix Connector Operations
UA	universal adapter
WR	war reserve

Characteristic and Development Report SA3581/MC4196 Lightning Arrestor Connector (LAC)

1. Introduction

MC4196 lightning arrestor connector (LAC) development activities started in FY88 to support the MC4078 LAC and surge protector device. The MC4078 is a major component in the CF2904 cable assembly.

The MC4196 is a chemically prepared varistor particle LAC (Figure 1) which was designed for the W89 SRAM II Program. This LAC subassembly employs the LJT17-26 contact pattern and is designated SA3581. Major external differences between this LAC connector and other LACs are its length and the addition of a stainless-steel hood over the blue insert assembly that provides electrostatic discharge (ESD) protection along with insert retention. Internally, chemically prepared varistor material (chem-prep) is used for a controlled electrical breakdown under high voltage surge conditions. Additionally, the web that contains the varistor material is welded in place. The double-ended contact design incorporates four tines; this eliminates a one-point contact interface used on standard LJT connectors.

2. Design

The MC4196 consists of the SA3581 hermetically sealed subassembly and LAC components. The SA3581 connector (LJT07H-17-26S) is defined under drawing number 411447. Connectors are purchased from Amphenol-Bendix Connector Operations (BCO) in Sidney, New York

The SA3581 connector design utilizes a double-ended socket contact insert assembly that provides four points of contact at the interfaces between the male/female electrical circuits. This type of contact design has been used successfully on commercial and special Sandia applications in the past. The standard LJT contact configuration of one-point contact has a history of galling the male contact and producing metallic flakes that result in inconsistent contact resistance values. The double-ended contact assemblies are molded in place with blue fiberite thermosetting insulating material into a metal ESD hood (Figure 2) that becomes an integral part of the insert assembly.

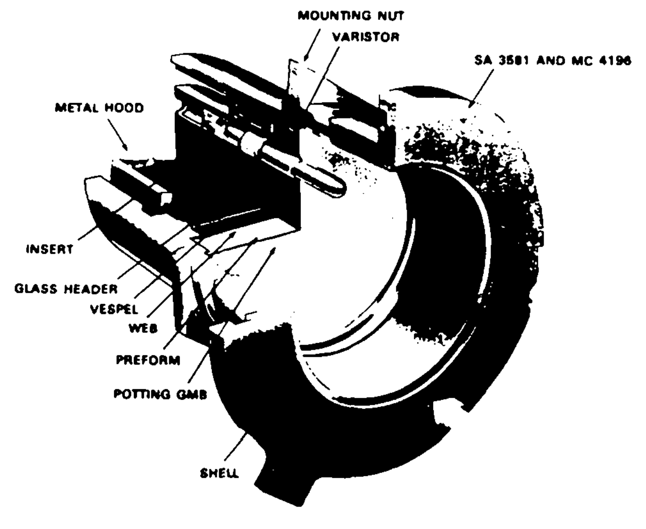


Figure 1. MC4196 Lightning Arrestor Connector

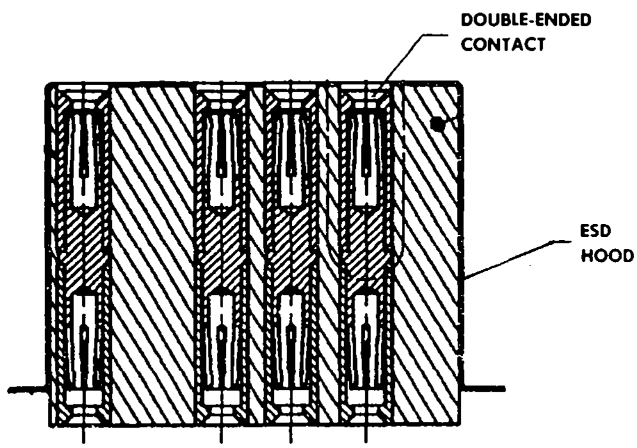


Figure 2. SA3581 Insert Assembly

The hood is welded in place using a laser welding operation (Appendix A). Welding of the hood ensures a ground plane between the shell and insert assembly while precluding damage and movement of the insert assembly. An interfacial gasket seal between the glass and insert assembly provides dielectric standoff and a moisture barrier for the contact pattern. The contacts where they exit the glass on the backend are notched to allow for straightening subsequent to the MC4196 processing operations.

The SA3581 features a smooth surface around the outside of the connector barrel immediately adjacent to the O-ring and mounting nut locations. This design provides EMR protection after installation of the assembly with its special mounting hardware in the W89 system. Subsequent testing revealed that this feature was unnecessary because the intimate contact and recessed mounting location afford adequate EMR protection. Because of cost and schedules, a new design to eliminate these special EMR features (belt and suspenders) was not created. An anti-rotational tab was incorporated on the shell at the request of the system designers; the tab provides a higher torquing value than the original D-flat configuration.

New processes were developed specifically for the MC4196. Chemically prepared varistor granule material replaced the mixed oxide material used in other LACs due to it's nearly 100% yield capability and an improvement in insulation resistance. A laser-welding process was developed to secure the web to the connector housing. Laser welding the web/disc assembly eliminates the need for machining internal threads in the connector housing and fabricating a retainer and washer that are standard in all other LACs for securing the web/disc assembly. Using the laser-welding process to join the web to the connector housing also reduces the possibility of generating metallic particulates during LAC assembly and improves the electrical conduction path between the web and connector.

Since the SA3642 adapter module (surge protection and filtering module) will be inserted into the rear of the MC4196 LAC (Figure 3), a new encapsulation process was developed to prevent possible damage to the varistor particles when aligning the contacts between the two components. The average potting level was reduced from 0.375 to 0.150 ± 0.020 for the encapsulant. In order to support these requirements, the mix of 828/carboxyl terminated butadiene acrylonitrile (CTBN)/glass microsphere (GMB)/ diethanolamine (DEA) was chosen as the encapsulant. This encapsulant replaced the less rigid epoxy and polyurethane encapsulation system and meets the new environmental safety requirements.

Appendix B lists in detail the complete product configuration system for the SA3581 connector and MC4196 LAC.

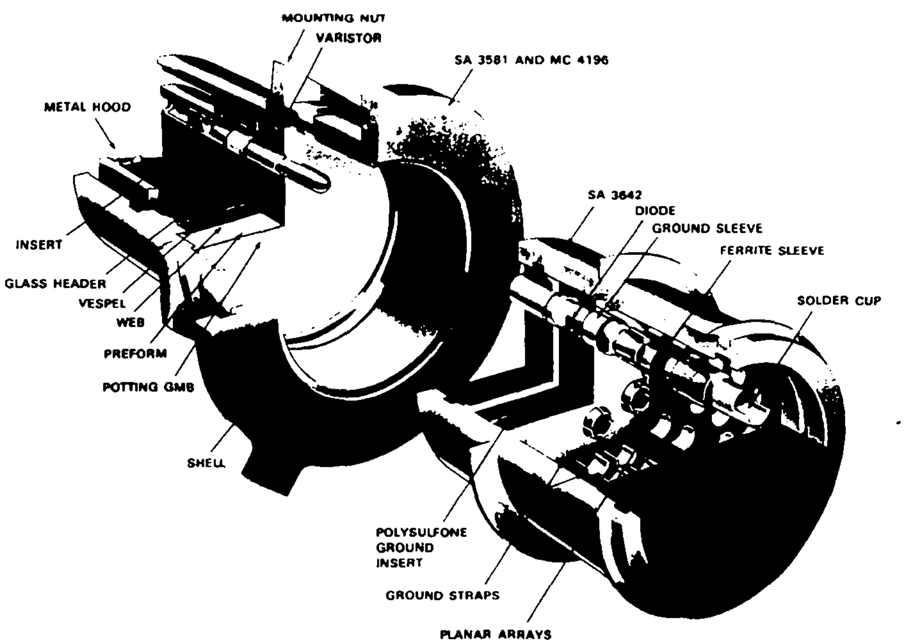


Figure 3. MC4078/MC4196 LAC and SA3642 Surge Protector

3. Development Program

The development program was divided into four phases as defined in Task authorization number 1412-400. Data obtained from Phase 1 determined the direction of Phase 2 processing parameters. This process continued for Phases 3 and 4 as well. Development specifications were written for both the SA3581 connector (DS411447) and the MC4196 LAC (DS412084). The SA3581 insert assembly defined product acceptance test parameters. Reliability of the MC4196 LAC was paramount and relied on the SA3581 to meet its design and margin testing requirements. Because of staffing changes, low manufacturing priorities, poor quality procedures, lack of documentation and little operator training, the SA3581 as manufactured by Amphenol-BCO was plagued with processing and performance problems. These problems are documented in Section 4.

The basic design was presented as two distinct assemblies where the LAC (MC4196) and surge/filter module (SA3642) would be subassemblies of the MC4078 LAC/surge device (Figure 3). A development program was presented and agreed upon by all component engineers: Sandia National Laboratories (SNL), Allied Signal Kansas City Division (KCD), Martin Marietta Specialty Components, Inc. (MMSC), Pinellas Plant (PP), and Amphenol-Bendix Connector Operations (BCO). The program's four distinct phases are described below.

Phase 1 was defined as the Design and Process Assessment Phase. During this phase, the complete MC4196 design package was reviewed for fit and function including detail and assembly drawings, specifications, materials, processes and manufacturing requirements. To complete this phase of the development program, fifteen SA3581 connectors were processed at BCO and delivered to MMSC for assembly into MC4196, which includes laser welding, encapsulation, tooling, fixtures and assembly process development.

Phases 2, 3, and 4 were based on actual fabrication, assembly, test, and evaluation of the SA3581 connector and MC4196 LACs. The combination of connector and LACs are identified later as Groups 1 through 3.

In Phase 2, Group 1 LAC units were fabricated with mixed oxide varistor material. This material exhibits desired qualities, but varistor granule yields have always been marginal. Therefore, in parallel with the MC4196 Development Plan, a project was instituted to replace mixed oxide varistor processing with chemically prepared varistor granules. The chemically prepared varistor material features 98% yields and improved insulation resistance (IR) in the LAC application. Data obtained from Phases 3 and 4 (Groups 2 and 3) used the new chem-prep varistor material which met all expectations.

4. Manufacturing Processes

4.1 SA3581 Connector Assembly at BCO

The SA3581 connector shells, contacts, contact insert assembly, retaining nuts, seals, and gaskets are manufactured at BCO. The fusing glass preform and drawn metal hood are purchased from outside vendors per BCO drawings. The contact pins are fused into the connector shell, plated, and the contact insert assembly is laser welded into the connector at BCO.

Manufacturing processes (Table 1) were established on Development Groups 1, 2, 3, and Proof of Development Build Lot. BCO developed manufacturing process sheets at the request of MMSC and SNLA. BCO operators were not trained in the use of the double-fusing fixtures that are required to maintain contact pin concentricity and location. Because of bent pins, glass see throughs, pins inserted upside down, and uncleaned fixtures resulting in IR failures, several runs had to be scrapped. Although the manufacturing process sheets were very thorough and were easily accessible, the operators went by repetition and did not always follow documented procedures.

4.2 MC4196 LAC Assembly at MMSC

MC4196 piece parts are manufactured at MMSC and all varistor materials used for development and production are formulated at MMSC. Piece parts consist of a web/disk assembly and a teflon disk. The disk is punched from 0.010-inch thick sheet stock. Figure 4 describes the operations required to fabricate the web/disk assembly, teflon disk, and final processing of the SA3581 connector assembly into the MC4196 LAC. Based on this process flow, production operating instructions were generated into the MMSC manufacturing system.

Table 1. SA3581 Manufacturing Process Flow

MIN LOT QTY		COST STD	REC QTY		REMARKS
BASIS	DATE 2/28/90	CHANGE ENG	SYM PRO	BURD CODE	RT CARD QTY
PART NUMBER 10-5672146-26s		NAME CONNECTOR, HERMETIC			

OPERATION NAME	PROD HR	HRS 100	MACH CODE	OPER #	DEPT
DEGREASE			78-08	A 001	51
CLEAN			27-00	A 013	51
PRE-OXIDIZE			28-01	A 390	51
ASSEM IN FIX			27-00	A 433	51
FUSE			28-01	A 007	51
REM FROM FIX			17-37	A 008	51
PERMANGANATE			30-01	A 310	32
MASK			27-00	A 322	32
ELEC POLISH			30-46	A 009	32
REMOVE MASK			27-00	A 323	32
WIRE CONTACTS			27-00	A 113	32
PLATE CONTACTS			30-32	A 246	32
REMOVE WIRE			27-00	A 116	32
STRIP IMM GOLD			30-01	A 330	32
CLEAN			27-00	A 418	32
IN PROCESS CHK			27-00	A 808	32
CLEAN			27-00	A 018	32
ELECTRIC TEST			23-00	A 431	09
LEAK TEST			70-81	A 204	09
CLEAN SEAL			70-81	A 232	50
APPLY ADHESIVE			78-11	A 235	50
DRY ADHESIVE			27-00	A 236	50
CLEAN GLASS			78-07	A 234	51
BAKE ASSEMBLY			25-58	A 238	51
ASSEM IN FIX			27-00	A 434	51
CUBE ASSEMBLY			25-58	A 239	51
REM FROM FIX			27-00	A 240	51
ASSEMBLE INSERT			27-00	A 427	51
LASER WELD			75-28	A 428	33
INSPECT			23-00	A 432	09
ASSEMBLE PACKING			27-00	A 220	51
ASSEMBLE NUT			27-00	A 042	51
INK STAMP			66-14	A 407	22
BAKE			25-58	A 295	22
ELECT TEST			23-00	A 430	G9
INSPECT			23-00	A 070	G9
PACKAGE CONN			27-00	A 140	51

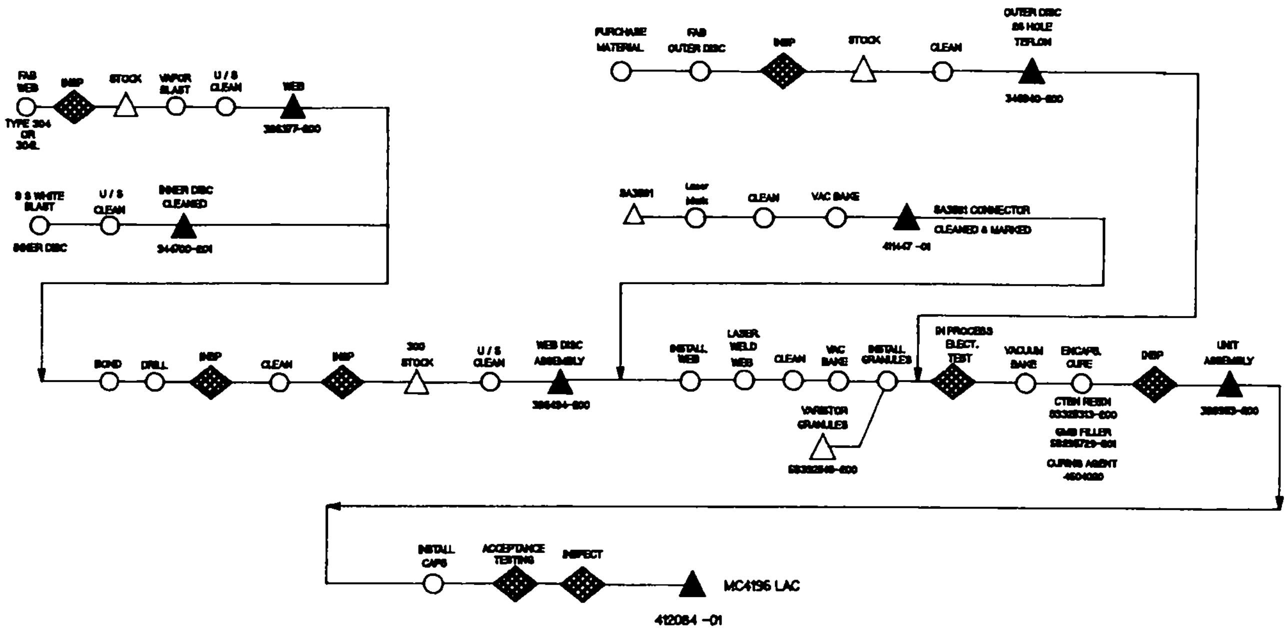


Figure 4. Manufacturing Process Flow, MC4196 LAC

5. SA3581 Incoming Acceptance

After SA3581 connectors are fabricated, in-process testing and inspection are performed by Amphenol-BCO. The connector is then subjected to final lot acceptance tests and inspection per PS411447. Lot acceptance testing with the exception of the coupling and test prod damage which are accomplished at BCO, are the first tests performed upon arrival of the SA3581s at MMSC. Lot acceptance tests, performance testing and mechanical inspection are performed to ensure compliance to PS411447-000 and Drawing 411447-01 before further processing is done.

5.1 Incoming Test and Inspection—MMSC (See Appendix C.)

Three distinctive groups were received at MMSC from BCO. All groups were procured from BCO on a Sandia Corporation Purchase Order (P.O. 63-0759). Work was completed in incoming test and inspection (ITI) on October 30, 1991.

5.2 Documents Required of BCO

Test records are supplied as required in PS411447-000 on DF411447-000 reports of 100% test rejects and records of destructive testing at BCO. The universal connector data form DF269657-001 has been incorporated into the drawing set.

5.3 Test and Inspection

Test and inspection at BCO is performed on testers and gages that are calibrated and controlled by BCO. Test and inspection at MMSC is defined in the "Quality Plan" as defined in FC914, 411447 Rev B, issued on 8/15/91. This document meets "QC One" requirements to assure the SA3581 connectors conformance to drawing definition 411447-01 and document PS411447-000.

6. SA3581/MC4196 Acceptance Equipment

6.1 SA3581/MC4196 Environmental Testers

Lot sample environmental tests are: (1) mechanical shock is performed 272×289 FHVA; (2) random vibration is performed on any available Building 200 shaker meeting SA3581 parameters; (3) temperature shock is performed during incoming test and inspection (ITI) within the 494×435 chamber. The same mechanical shock and random vibration systems will be utilized for MC4196 LAC lot sample test conditioning.

6.2 SA3581 Acceptance Testing and Gaging

Upon completion of successful lot sample tests, acceptance testing and gaging, insulation resistance (IR), 100% and dielectric withstanding tests are performed on tester 494×199 (Figure 5) or 372×309 (Figure 6) which have been EQed and are defined and calibrated at MMSC. Contact resistance is performed at 100% on a commercially acquired Hewlett Packard Model 4274 Frequency LCR Meter (Figure 7) using dedicated test fixtures (UA5902-000 and UA6116-000). An identical system is used for MC4196 LAC contact resistance testing. Three dedicated gages (MN411447-T1, T3, and T4) were designed, calibrated, and are controlled at MMSC for the SA3581.

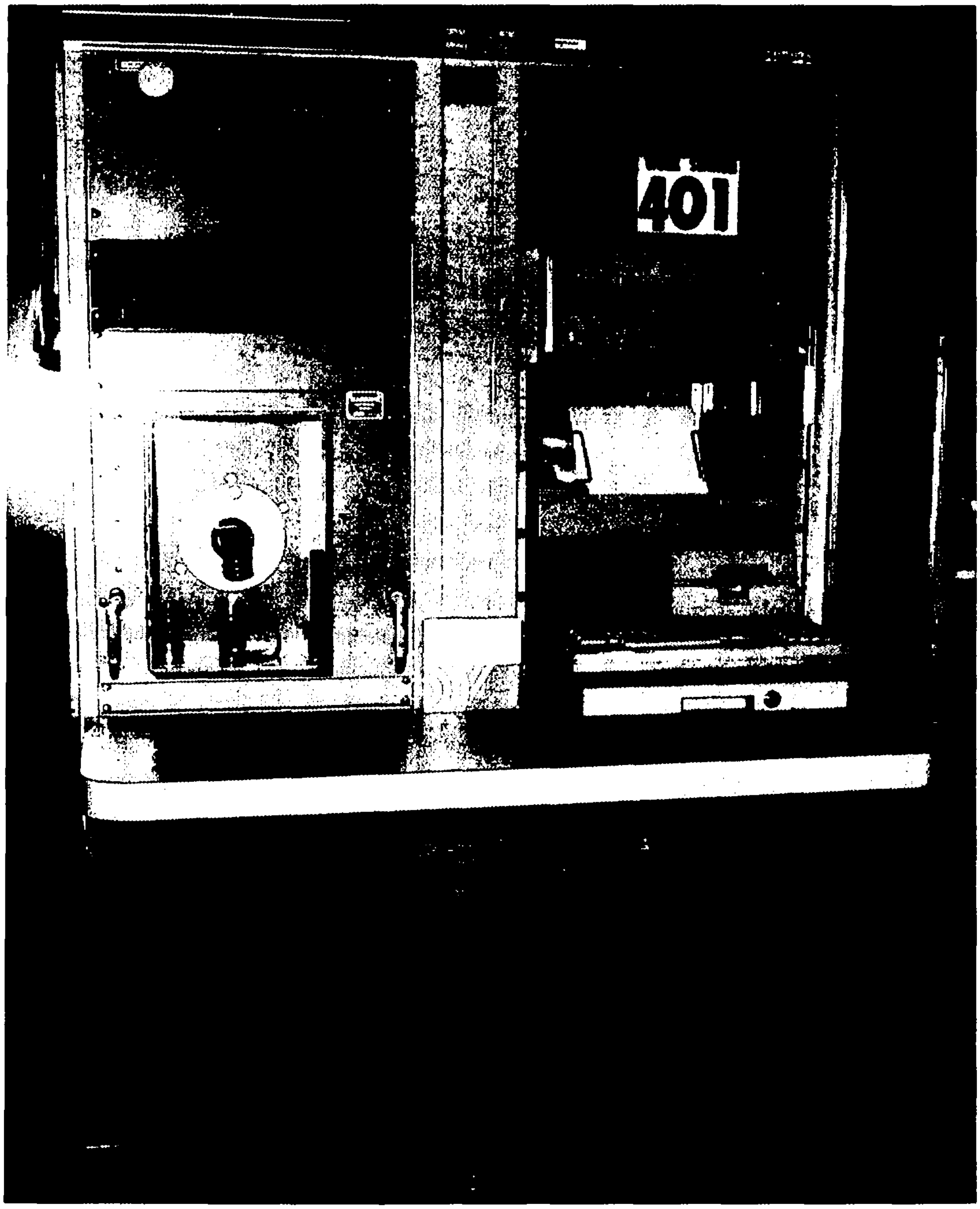


Figure 5. 494×199 Multi-Pin Connector Tester

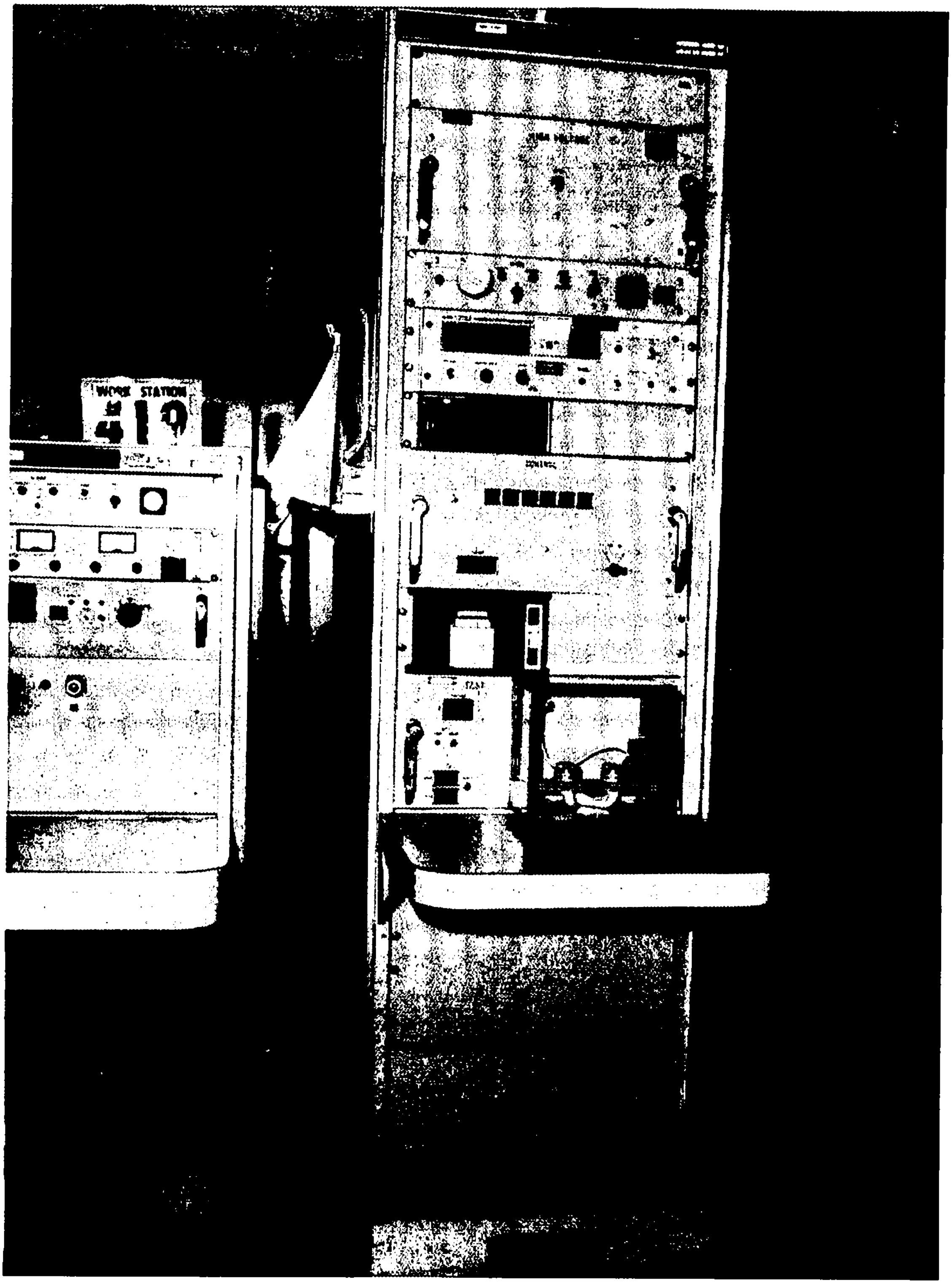


Figure 6. 372×309 SA Connector Test Position

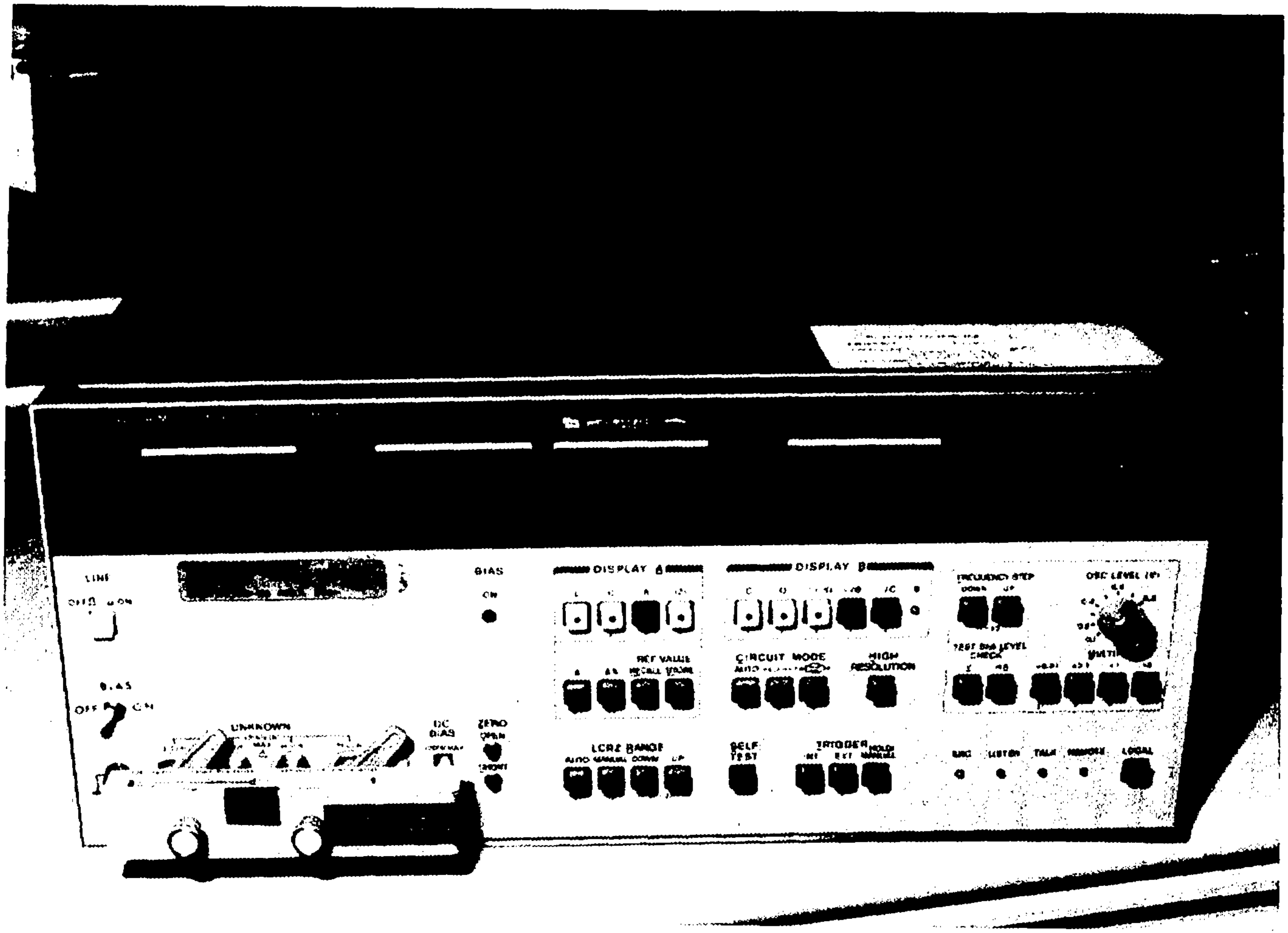


Figure 7. Hewlett Packard Model 4274 LCR Meter, UA 6116 Contact Resistance Tester

6.3 MC4196 Acceptance Testing and Gaging

On completing the MC4196, LAC fabrication, acceptance testing and gaging are accomplished. Also particle detection testing is then performed on the PT3166 particle detection tester (Figure 8). Insulation resistance, fast rise-time breakdown, and direct current voltage withstanding electrical testing are performed on the PT3290 LAC tester (Figure 9).

The backend gage, GA8255, was designed at MMSC and assures true positioning of the backend pin arrangement. CER/DTER 911138SA was received from Sandia Engineers: Paul Konnick (2551), Jack Gallagher (2545), and Sherwood Duliere (7253). Paul Konnick and L. K. Bradley (MMSC) have observed the gage in use and find that it functions properly. QER 920962SA was received in July 1992.

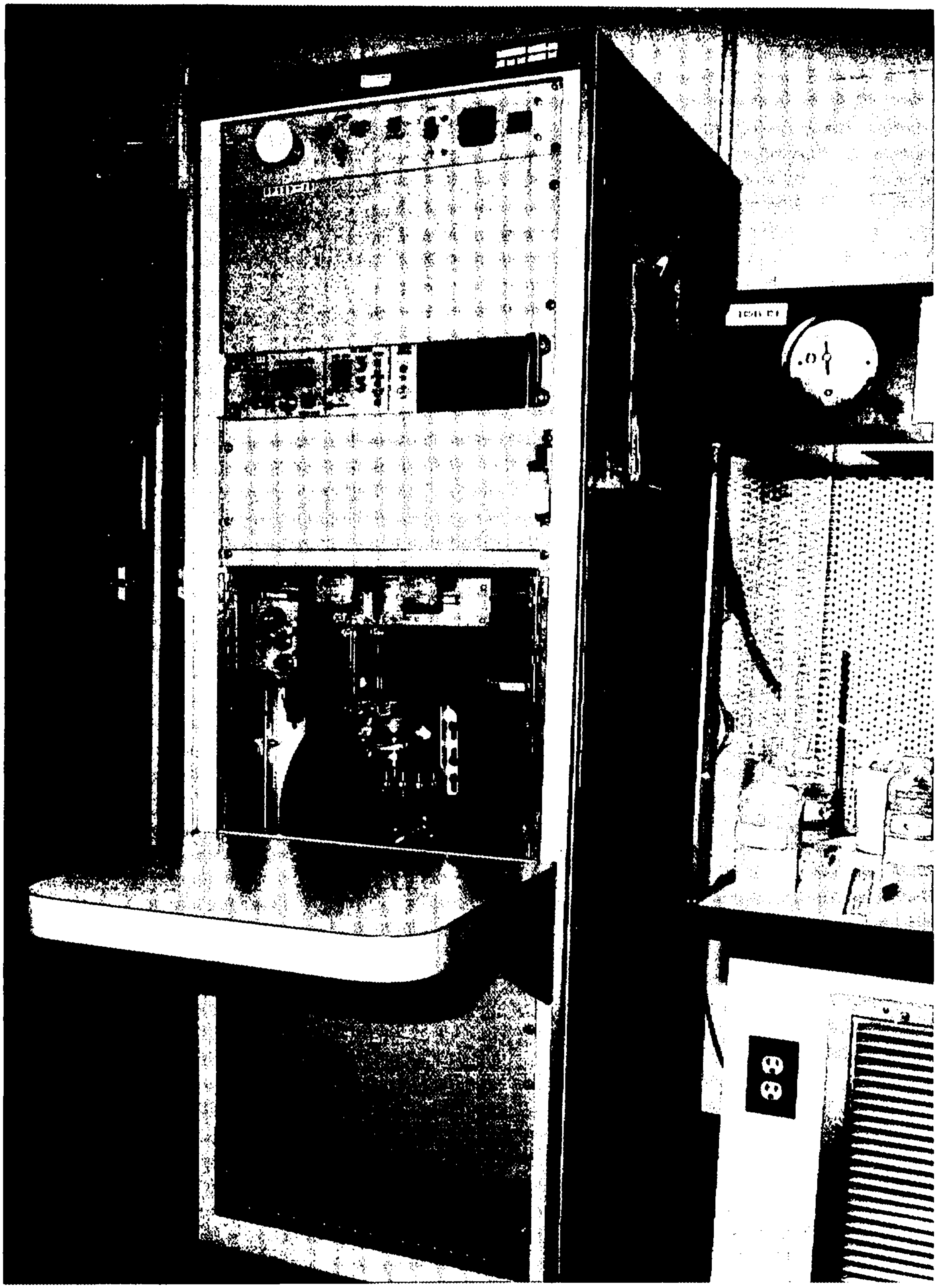


Figure 8. PT3166 Particle Detection Tester

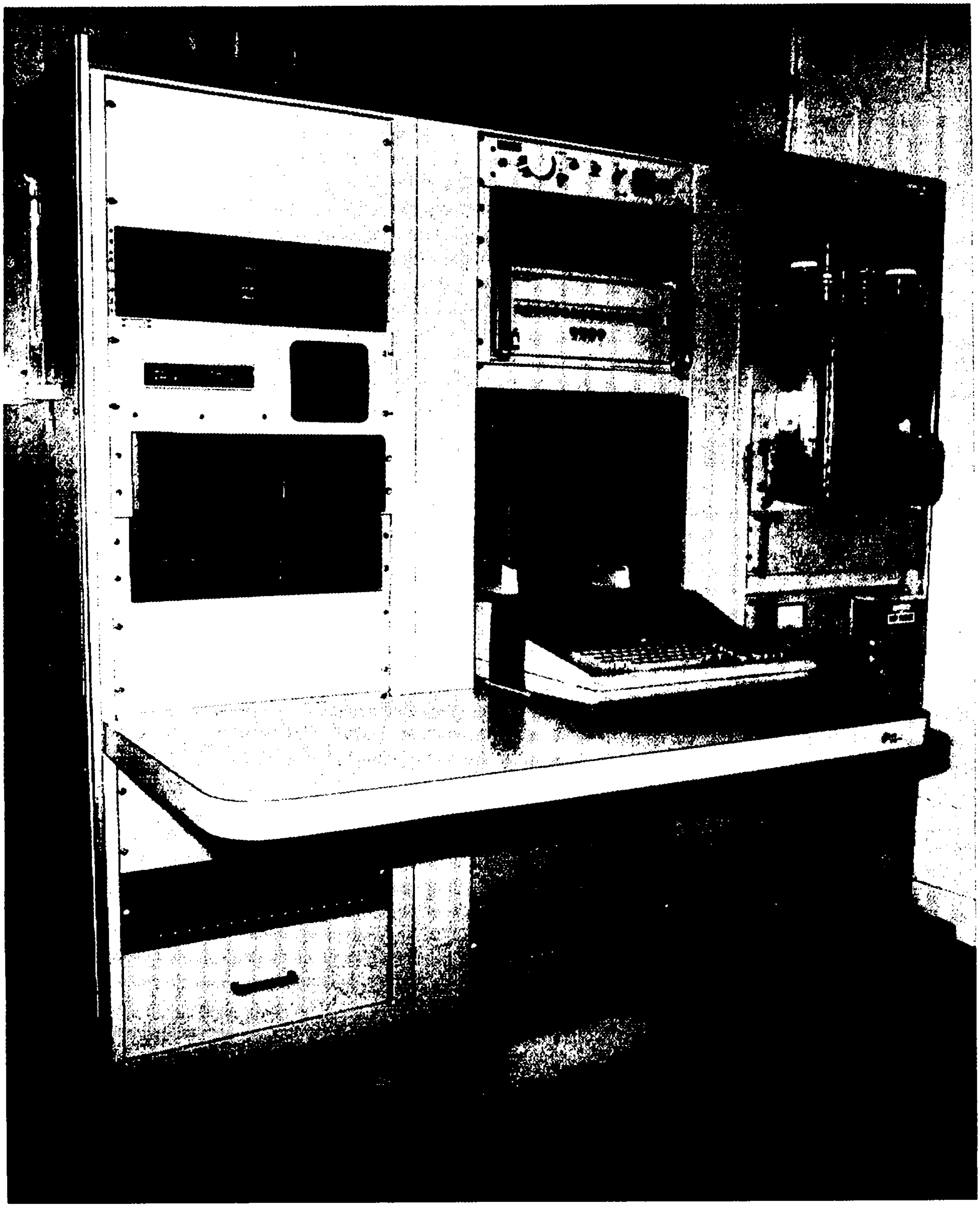


Figure 9. PT3290 LAC Tester

7. Test Results

7.1 Phase 1—Process Development

A total of fifteen (15) SA3581 connectors were received for laser welding, encapsulation, and assembly process development. Two (2) were used for encapsulation fixturing, one (1) for environmental fixturing, and twelve (12) for evaluating actual processing of connectors into functional LACs. Table 2 contains test results on the dummy connectors received for process development activities. Product acceptance specification values were DWV 1200 V ±60 Vdc, 2 sec, IR 8.0 gigaohms min.

Table 2. Connector Data (Process Development Units)

S/N (BCO)	S/N (MMSC)	Failure Mode
0104	D01	DWV < 500 V*
0150	D02	DWV < 500 V
0125	D03	DWV < 500 V
0105	D04	DWV < 500 V
0132	D05	DWV < 500 V
0113	D06	Degraded IR**
0143	D07	DWV < 500 V
0103	D08	Degraded IR
0140	D09	DWV < 500 V
0124	D10	DWV < 500 V
0127	D11	DWV < 500 V
0144	D12	DWV < 500 V
0116	D13	DWV < 500 V
0145	D14	Degraded IR
0135	D15	DWV < 500 V

*DWV - dielectric withstanding voltage
**Degraded IR: IR is less than 8.0 gigaohms

7.1.1 Set 1 Processing

Five (5) connectors were selected for the first functional process development build (Set 1). The connectors selected for this build were 955-D07-B89, 955-D09-B89, 955-D10-B89, 955-D14,B89 and 955-D15-B89. All five units were processed through laser welding, using processes developed with simulated parts. After laser welding, one unit was sectioned to evaluate weld penetration and web/disk positioning in the connector shell. MMSC found the web/disc assembly to be well positioned in the shell. From the MMSC evaluation of the sectioned connector, it was determined:

1) a need for more weld penetration
2) a need to verify power level of laser welder before welding
3) a need to have a web and connector flange free of burrs and with a maximum radius of 0.005.

The remaining four units were cleaned, filled with mixed oxide varistor granules (SS349598-200), and subjected to in-process electrical testing (Table 3). The units were then forwarded to the Materials Lab for encapsulation. Several LACs with the 26-pin configuration were encapsulated with the new encapsulant (828/CTBN/GMB/DEA) before processing these units. The same pneumatic dispensing equipment used with current encapsulants was employed with the addition of a heating block to improve flow through the syringe. All four units were free of voids and within the required potting level which was 0.150 ± 0.020. After encapsulation, the units were subjected to acceptance type testing (Table 4). Three of the units passed, but one contact of 955-D07-B89 showed an abnormally high fast-rise breakdown voltage. The unit was forwarded to the Component Product Evaluation (CPE) Lab for defect analysis. The analysis revealed that the teflon disc had lifted off the web, allowing the granules to escape from the breakdown chamber of contact 15. Epoxy run-in was also noted in the breakdown chamber of contacts 14 and 15 (Figures 10 and 11). After reviewing the analysis and the encapsulation process, we realized that the 0.0695 diameter of the contact did not extend above the web far enough to seat the teflon disc properly.

The three remaining units were thermal cycled per DS412084. Temperature extremes were −49 to +84°C. LACs 955-D10-B89 and 955-D14-B89 were subjected to 20 cycles and 955-D15-B89, to 18 cycles (Table 5). One fast-rise breakdown failure (S/N D14) was detected (Table 6). Again, the loss of particles in the breakdown chamber was due to the teflon disc not seating properly. No insulation resistance failures occurred during the testing. After cycle 18, S/N 955-D15-B89 was shipped to BCO for processing.

7.1.1.1 Problems Identified During Processing of Development Units

1) Unable to use present pin straightening tool for centering pins after insertion of web/disk assembly
2) Unable to properly seat teflon disk around pins
3) Edge breaks on web and connector flange need to be controlled, as well as the web's flange thickness
4) Inadequate weld penetration

Table 3. In-Process Electrical Testing (Process Development Units)

S/N		CONN IR@125 V (Megohms)	CONN/WEB IR@125 V (Megohms)	AFTER WELD IR@125 V (Megohms)	IN-PROCESS IR@125 V (Megohms)	IN-PROCESS FRB (V)
	Max.	1302350	1390120	1989812	6051	948
D07	Avg.	1142986	1208659	1466700	3019	892
	Min.	1052986	1169754	1223331	752	807
	Max.	1248751	1356483	1812382	8135	966
D10	Avg.	1103291	1242651	1592385	4881	914
	Min.	1006603	1099191	1204587	1744	844
	Max.	1358105	1403548	1766285	5059	942
D14	Avg.	1121800	1185958	1454699	2696	886
	Min.	1022327	1040972	1301134	599	764
	Max.	1328515	1324012	1701606	7586	973
D15	Avg.	1140580	1174750	1418767	4277	890
	Min.	1081034	1097550	1223930	1507	790

Table 4. Acceptance Type Testing (Process Development Units)

S/N		IR@125 V (Megohms)	FRB (V)	IR@125 V (Megohms)
	Max.	10735	1022	1869
D07*	Avg.	1103	847	166
	Min.	166	743	9
	Max.	1934	967	250
D10	Avg.	1021	887	147
	Min.	359	811	28
	Max.	8553	899	492
D14	Avg.	1925	822	263
	Min.	388	660	22
	Max.	5028	941	786
D15	Avg.	182	854	298
	Min.	247	793	29

*Insufficient level of particles in breakdown chamber

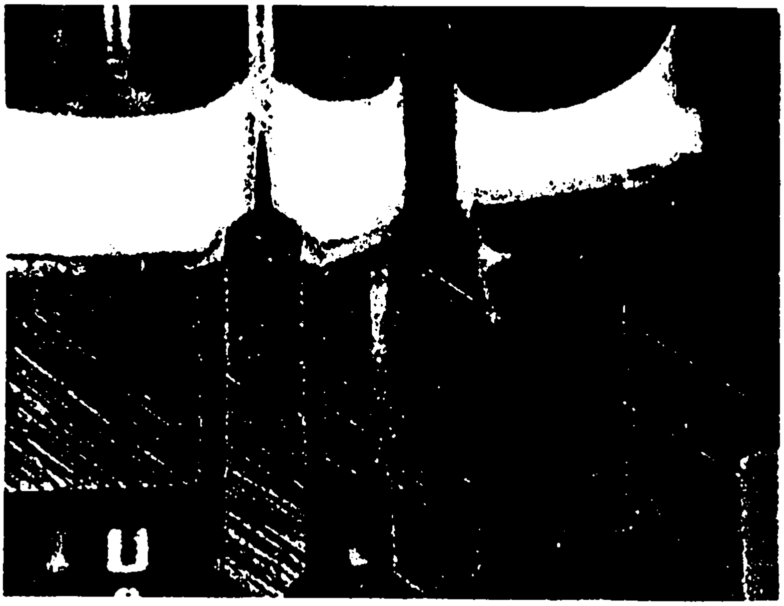


Figure 10. Teflon Lifting Off Web and Epoxy Run-In (Pin 14)

Figure 11. Teflon Lifting Off Web and Epoxy Run-In (Pin 15)

Table 5. Thermal Cycling Data (Process Development Units)

INSULATION RESISTANCE (Megohms)

S/N		Cycle 4	Cycle 7	Cycle 15	Cycle 18	Cycle 20
	Max.	2028	1625	1587	1739	1310
D10	Avg.	1034	876	768	716	593
	Min.	177	36	13	66	55
	Max.	14007	3050	2335	2080	2534
D14	Avg.	2495	1836	1141	998	941
	Min.	516	696	289	330	188
	Max.	3228	3687	3448	3066	
D15	Avg.	1491	1438	1200	1109	
	Min.	595	100	83	47	

Table 6. Thermal Cycling Data (Process Development Units)

FAST-RISE BREAKDOWN (V)

S/N		Cycle 4	Cycle 7	Cycle 15	Cycle 18	Cycle 20
	Max.	957	971	968	945	972
D10	Avg.	882	877	880	872	869
	Min.	817	803	806	789	812
	Max.	939	999	1192	1038	1062
D14*	Avg.	841	843	834	813	824
	Min.	747	763	688	651	734
	Max.	933	921	925	915	
D15	Avg.	842	834	836	834	
	Min.	747	763	753	777	

*Contact failed FRB testing, maximum allowable per DS is 1100 Vdc.

7.1.1.2 Corrective Action

1) To aid pin straightening and seating of the teflon disc, the 0.0695 diameter of the pin must be lengthened a minimum of 0.100.
2) Design a new tool for initial alignment of the pin, and use present tool for final alignment.
3) Change web drawing to specify a maximum radius of 0.005 and the web flange to a thickness of 0.015 +0.000/−0.003.
4) Increase power level of the laser welder to increase weld penetration

7.1.2 Set 2 Processing

Set 2 consisted of three connectors. The connectors selected were 955-D03-B89, 955-D04-B89, and 955-D08-B89. The primary purpose of processing these units was to increase weld penetration and integrity. One unit was sectioned after laser weld and the remaining two were processed through encapsulation. Figure 12 is a photo of one of the welds. The penetration is about 0.005 into the shell flange. Some microcracking was observed during the analysis. After processing Set 2 units, MMSC discovered that the laser welder was malfunctioning during the welding of Set 1 and 2 process development units. This accounted for the decreased penetration encountered during the laser welding of Set 1 units. The welding parameters were later optimized during the processing of the Phase 2 — Group 1 units due to scheduling.

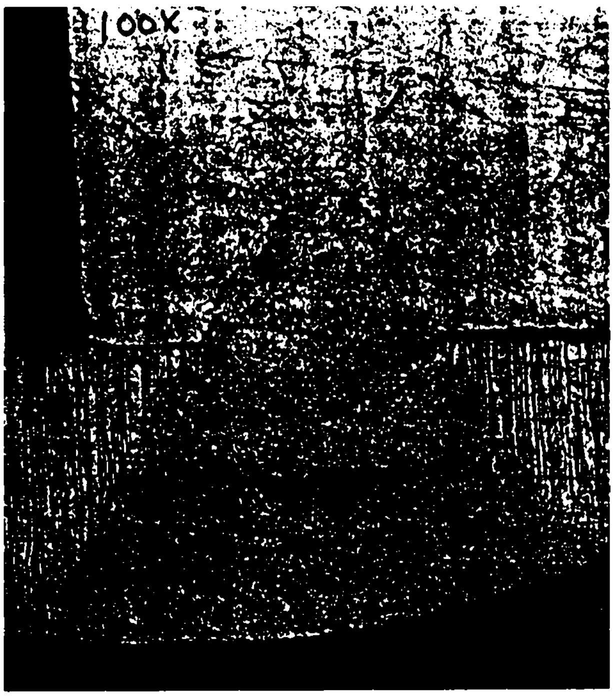


Figure 12. Weld Penetration

7.2 Phase 2 — Group 1

Thirty-three SA3581 connectors were received from BCO as Phase 2 — Group 1 units for the first development build. All thirty-three (33) SA3581 connectors were serialized (Table 7) and forwarded to MMSC's Incoming and Inspection laboratory. The incoming test and inspection process was based on a modified SA3581 Development Specification, DS411447, and on a modified SA3037 connector product specification (PS 318828). The testing covered four main areas: visual inspection, electrical, hermeticity, and dimensional. Connectors were not subjected to D-tests such as test prod damage and temperature cycling.

Table 7. BCO and MMSC Serial Number for Group 1

S/N (MMSC)	S/N (BCO)	S/N (MMSC)	S/N (BCO)
D01	142	D18	138
D02	128	D19	126
D03	136	D20	106
D04	149	D21	111
D05	137	D22	133
D06	146	D23	117
D07	102	D24	110
D08	130	D25	108
D09	134	D26	120
D10	151	D27	107
D11	121	D28	114
D12	139	D29	115
D13	148	D30	118
D14	123	D31	147
D15	122	D32	158
D16	109	D33	154
D17	129		

7.2.1 Electrical Testing of Connectors

All 33 connectors were subjected to three types of electrical tests: insulation resistance, dielectric withstanding voltage (DWV), and contact resistance.

7.2.2 Insulation Resistance Testing

Insulation resistance testing was performed at 500 Vdc. Each contact was required to have a minimum IR of 8000 megohms. All 33 units passed insulation resistance testing.

7.2.3 Dielectric Withstanding Voltage Testing

Dielectric withstanding voltage testing detects contamination within or on the surface of the glass and hold-off capability between the hood and contact. This test subjects each contact (pin) to 1200 $\pm 5\%$ Vdc for 2 seconds, minimum. Contact 10 of S/N 0120 and contact 3 of S/N 0134 failed dielectric withstanding voltage testing. Testing was performed without an interfacial gasket between the SA3581 connector and the test adaptor, but the breakdowns did not appear to be across the hood interface.

7.2.4 Contact Resistance Testing

Contact resistance testing measures the electrical resistance of each pair of mated contacts (SA3581 connector and its mating connector) by measuring, at the extreme ends, the voltage drop across the contacts while they carry five amps of current. The maximum voltage drop is not to exceed 65 millivolts. No failures were detected during contact resistance testing.

7.2.5 Helium Leakage

The hermeticity testing consisted of performing a helium leak check on all 33 connectors. The maximum leak allowed is 10^{-6} cc/s. No failures were detected during helium leak checking.

7.2.6 MC4196 Fabrication and Test Results

Table 7 shows the BCO and MMSC serial number for each of the 33 connectors processed. The only material change as a result of process development activities was the teflon disc. A standard teflon disc is 0.010 inch thick. For the Phase 2 – Group 1 units, a 0.031-inch-thick teflon disc was used since the 0.0695 contact diameter of Group 1 units was the same as the process development units. Increasing the thickness made the disc more rigid and less dependent on the 0.0695 contact diameter (employed to prevent epoxy run-in and/or particles loss from breakdown chamber). No major problems were encountered during processing. Evaluative testing consisted of the following electrical test sequence:

Insulation resistance (IR1) @ 125 V
DC voltage withstanding (DCWV) @ 100 V
Fast rise-time breakdown
Insulation resistance (IR2) @ 125 V

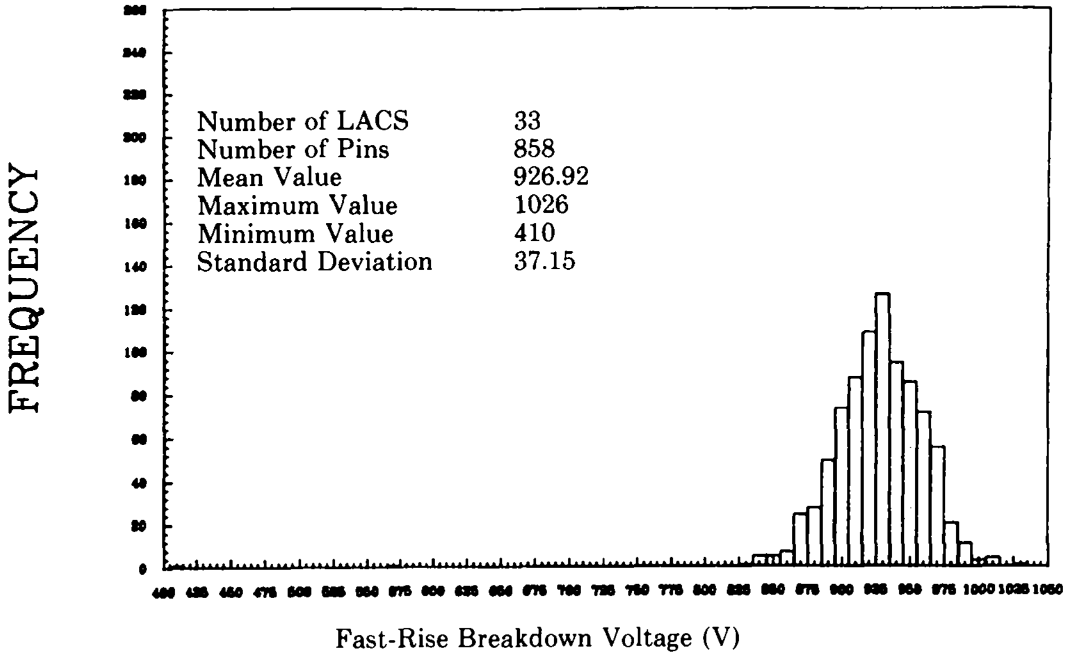
Figure 13 contains plots of in-process and acceptance (evaluative) FRB test data for the 33 MC4196 LACs. Tables 8 through 10 summarize the insulation resistance testing during processing. Minimum IR per DS412084 is 2 megohms. IR testing was also used during processing as a status indicator to determine process cleanliness and repeatability. A 500 V IR test was performed after each processing sequence prior to filling the chambers with varistor particles.

Four (4) units were subjected to various environmental tests per Development Specification, MC4196 (DS412084). No physical damage or electrical failures occurred during the testing. The following units were selected for environmental testing from Phase 2 – Group 1: 962-D07-B89, 962-D09-B89, 962-D16-B89 and 962-D26-B89. Table 11 contains the evaluative test results for the four units subjected to D-Test. DCWV testing was not performed on 962-D09-B89 and 962-D16-B89, due to a shorted contact on each LAC. These units failed DWV during incoming inspection of the connectors.

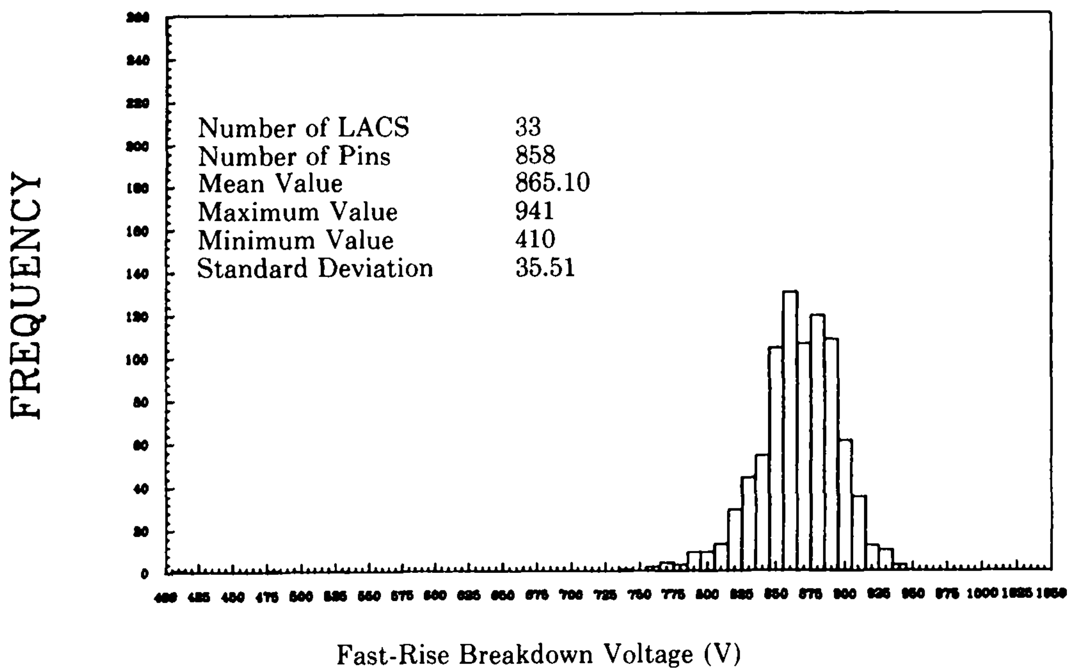
During the processing and testing of Phase 2 – Group 1 units the problems were identified in the following sections.

7.2.6.1 Problems Identified During Processing of Phase 2 – Group 1

1) Unable to use standard pin straightening tool for centering pins after installing the web/disc assembly.
2) Unable to seat teflon disc around contacts (pins).
3) Edge breaks on web and connector flange needed to be controlled, as well as the web's flange thickness.
4) Limited weld penetration.
5) Need for a better cleaning process during and after laser welding.



a) Group 1 In-Process



b) Group 1 Acceptance

Figure 13. FRB Test Data (Group 1)

Table 8. In-Process Insulation Resistance

Range Lower Limit	Range Upper Limit	Pins Within Range	Pins Below Upper Limit	LACs Within Range	LACs Below Upper Limit
0	4	2	2	2	2
4	7	0	2	0	2
7	10	0	2	0	2
10	40	0	2	0	2
40	70	0	2	0	2
70	100	0	2	0	2
100	400	0	2	0	2
400	700	0	2	0	2
700	1000	0	2	0	2
1000	4000	99	101	18	18
4000	7000	285	386	20	20
7000	10000	125	511	15	20
10000	40000	91	602	17	31
40000	70000	200	802	13	33
70000	100000	0	802	0	33
100000	400000	5	807	3	33
400000	700000	51	858	3	33
700000	1000000	0	858	0	33

MC Type	MC4196	
Num of LACs	= 33	
Num of Pins	= 858	Pin 3: 962-D09-B89 (Shorted)
Mean Value	= 49344	Pin 10: 962-D26-B89 (Shorted)
STD DEV	= 116033	
Max. Value	= 639975	
Min. Value	= 0	

Table 9. Acceptance Insulation Resistance (IR1)

Range Lower Limit	Range Upper Limit	Pins Pins Within Range	LACs Below Upper Limit	LACs Within Range	Below Upper Limit
0	4	2	2	2	2
4	7	0	2	0	2
7	10	0	2	0	2
10	40	0	2	0	2
40	70	0	2	0	2
70	100	0	2	0	2
100	400	0	2	0	2
400	700	0	2	0	2
700	1000	0	2	0	2
1000	4000	0	2	0	2
4000	7000	0	2	0	2
7000	10000	0	2	0	2
10000	40000	1	3	1	3
40000	70000	3	6	3	6
70000	100000	0	6	0	6
100000	400000	8	14	7	11
400000	700000	380	394	31	31
700000	1000000	464	858	32	33

MC Type	MC4196	
Num of LACs	= 33	
Num of Pins	= 858	Pin 3: 962-D09-B89 (Shorted)
Mean Value	= 694068	Pin 10: 962-D26-B89 (Shorted)
STD DEV	= 111396	
Max. Value	= 973520	
Min. Value	= 0	

Table 10. Acceptance Insulation Resistance (IR2)

Range		Pins	Pins Below	LACs	LACs Below
Lower Limit	Upper Limit	Within Range	Upper Limit	Within Range	Upper Limit
0	4	2	2	2	2
4	7	0	2	0	2
7	10	0	2	0	2
10	40	0	2	0	2
40	70	0	2	0	2
70	100	0	2	0	2
100	400	1	3	1	3
400	700	0	3	0	3
700	1000	0	3	0	3
1000	4000	0	3	0	3
4000	7000	0	3	0	3
7000	10000	1	4	1	4
10000	40000	452	456	31	32
40000	70000	338	794	30	33
70000	100000	0	794	0	33
100000	400000	33	827	3	33
400000	700000	31	858	3	33
700000	1000000	0	858	0	33

MC Type MC4196
Num of LACs = 33
Num of Pins = 858
Mean Value = 65200
STD DEV = 96587
Max. Value = 698207
Min. Value = 0

Pin 3: 962-D09-B89 (Shorted)
Pin 10: 962-D26-B89 (Shorted)

Table 11. Summary of Post-Environmental Electrical Testing (Phase 2 — Group 1)

962-D07-B89

		Acceptance Data	Mech Shock I (375 g to 5 ms)	Random Vib I (2000 0.67g2 Hz)	Temp Cycle I (8 Cycles)
	Max.	791289	763405	847458	706294
IR1	Avg.	654632	651948	700385	576409
(125 V)	Min.	469061	490696	507285	409380
DCWV (100 V)	P/F	(P)	(P)	(P)	(P)
	Max.	908	897	904	883
FRB	Avg.	866	867	870	848
	Min.	827	794	823	777
	Sig.	20	22	19	25
	Max.	48553	47209	501545	33171
IR2	Avg.	34665	38471	212863	19847
(125 V)	Min.	27033	30710	32773	10847

962-D09-B89

		Acceptance Data	Mech Shock I (375 g to 5 ms)	Mech Shock II (560 g to 5 ms)
IR1	Max.	744225	803600	764339
(125 V)	Avg.	636066	679136	654985
	Max.	903	033	903
FRB	Avg.	831	857	855
IR2	Max.	41300	50086	54277
(125 V)	Avg.	31340	37937	37175

962-D16-B89

		Acceptance Data	Temp Cycle I (8 Cycles)	Temp Cycle II (40 Cycles)
IR1	Max.	800974	639353	380309
(125 V)	Avg.	709506	578931	26547
	Min.	514933	469189	18688
DCWV (100 V)	(P/F)	(P)	(P)	(P)
	Max.	882	882	859
FRB	Avg.	856	854	838
	Min.	828	836	806
	Sig.	15	12	12
IR2	Max.	47108	30300	11179
(125 V)	Avg.	37646	21321	6377
	Min.	29708	13430	2858

962-D26-B89

		Acceptance Data	Mech Shock I II (375 g to 5 ms)	Mech Shock (560 g to 5 ms)
IR1	Max.	770986	780713	901031
(125 V)	Avg.	678192	666540	789897
FRB	Max.	927	929	873
	Avg.	880	864	833
IR2	Max.	66592	55110	58053
(125 V)	Avg.	53423	43269	48842

7.2.6.2 Process Improvement

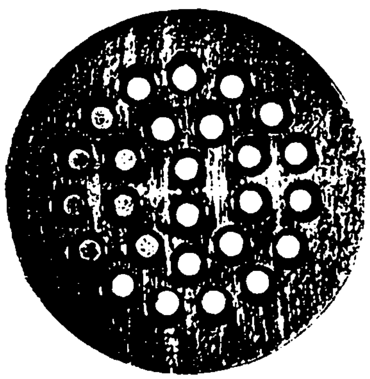
Process development activities prior to the arrival of Group 2 connectors focused on developing a reliable laser welding and cleaning process for joining the web/disc assembly to the connector shell and subsequent cleaning. Simulated piece parts were fabricated and laser welded. During visual inspection of the first group of simulated piece parts, there was no sure method of determining the integrity of the weld or a laser welder malfunction. In an effort to develop some visual inspection technique, the geometry of the web was modified. The web was redefined to include two notches, 180° apart. Figure 14 shows the original and the modified web design. The notches serve two purposes: 1) they provide some degree of visual inspection of the laser weld, and 2) they aid in aligning the web during insertion into the connector.

Once the new webs were fabricated, six more simulated assemblies were fabricated and laser welded Figure 15. The assemblies were then evaluated to determine the weld penetration into the shell flange and the force needed to separate the web/disc assembly from the shell flange.

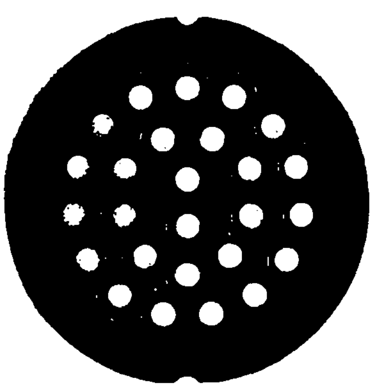
Three simulated assemblies were sectioned to determined the circumferential and depth penetration of the laser weld. Both weld width and penetration were evaluated. Weld width, as measured at the surface of the connector flange, varied between 10 and 14 mils. The penetration of the weld was a maximum of 0.0005 to 0.004 for 230°.

The remaining three assemblies were fixtured in a press to determine the force necessary to separate the web from the connector flange. The force required to break the web weld ranged from 900 to 2300 pounds. The lower force was obtained from a specimen that only had a minor amount of circumferential weld length penetration (60°). The larger number was obtained from a specimen with a nominal amount of circumferential weld length (180° to 230°).

Finally, to reduce contamination on the connector inner wall from the welding process, a brass shield was fabricated. The shield slips down the inner wall of the connector to approximately 0.100 inch above the web flange (see Figure 16).

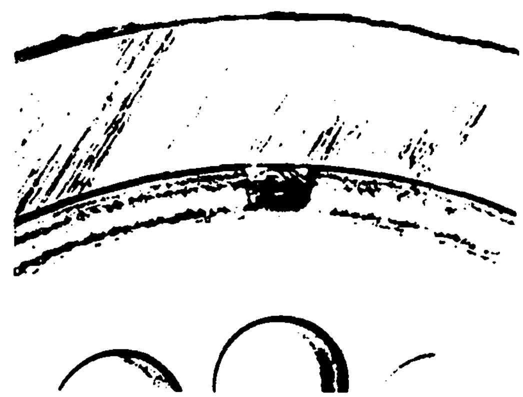


a) Without Notches (original)

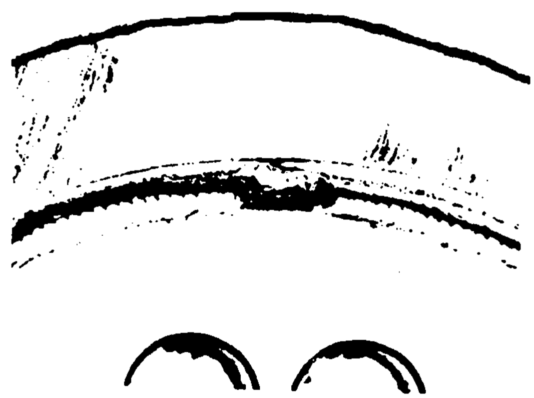


b) With Notches (modified)

Figure 14. Original and Modified Web Design



a) View of Weld Flow in Notch



b) View of Opposite Notch Weld Flow

Figure 15. Visual Inspection Notches of the Web Laser Weld

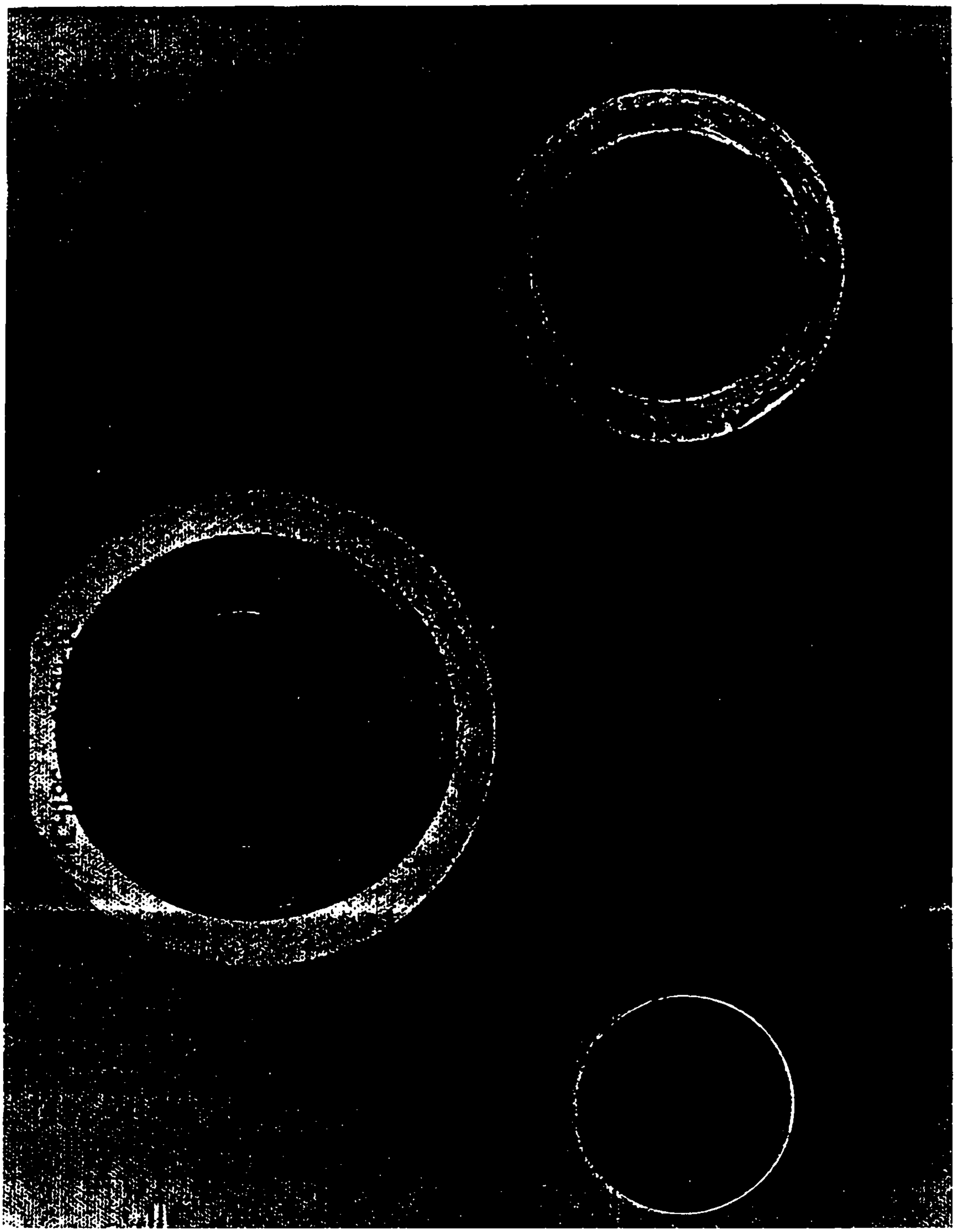


Figure 16. Laser Weld Shields

7.2.6.3 Corrective Action

1) Extended and tapered the 0.0695-diameter portion of the contact to aid teflon disc installation and pin (contact) centering. A new pin alignment tool was designed and fabricated to aid in the initial centering of pins.
2) Changed the geometry of the web to support weld penetration, alignment during installation, and to provide some method of visually inspecting the laser weld.
3) Modified contact shield and added another welding shield to aid cleaning during and after laser welding.
4) Employed chem-prep varistor particles.
5) Serialized on backend mounting flange, rather than around the barrel of the connector.
6) Marked contact designation on the metal hood.

7.3 Phase 3 — Group 2

Of the 33 Group 2 SA3581 connectors received, 23 were forwarded to the MMSC Incoming and Inspection Lab. The incoming test and inspection process was based on a modified SA3581 PS. The testing again covered four main areas: visual inspection, electrical, hermeticity, and dimensional checks. Connectors were not subjected to D-tests such as test prod damage and temperature cycling.

7.3.1 Electrical Testing of Connectors

Twenty-three connectors were subjected to three types of electrical tests: insulation resistance, dielectric withstanding voltage, and contact resistance.

Insulation resistance testing was performed at 500 ± 25 Vdc. Each contact was required to have a minimum IR of 8000 megohms, and all 23 units passed. Dielectric withstanding voltage testing detects contamination within or on the surface of the glass and hold-off capability between the hood and contact. This test subjects each contact (pin) to $1200 \pm 5\%$ Vdc for 2 seconds minimum. No failures were detected. Contact resistance testing measures the electrical resistance of each pair of mated contacts (SA3581 connector and its mating connector) by measuring, at the extreme ends, the voltage drop across the contacts while they are carrying 5 amps of current. The maximum voltage drop is not to exceed 65 millivolts. No failures were detected during contact resistance testing. The remaining 10 were retained in the LAC development lab for development activities.

7.3.2 Helium Leakage

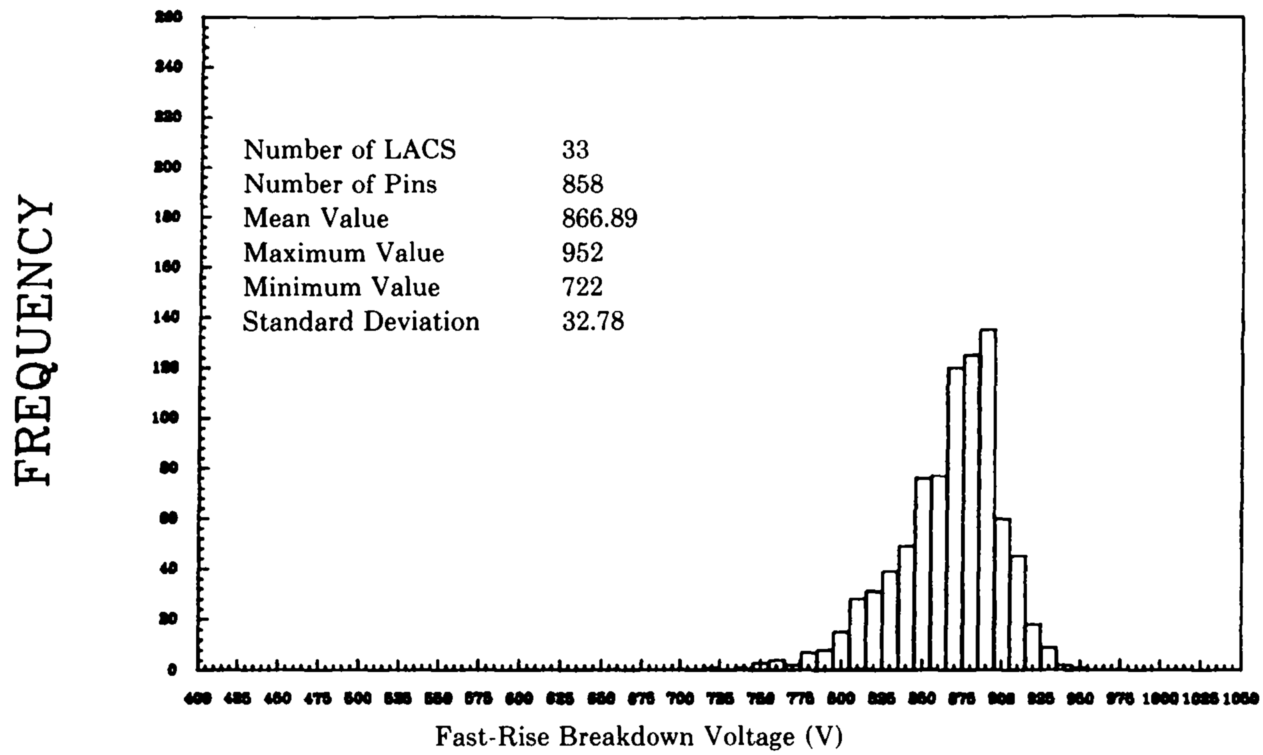
The hermeticity testing consisted of performing a helium leak check on 23 connectors. The maximum leak allowed is 10^{-6} cc/s. No failures were detected during leak testing.

7.3.3 MC4196 Fabrication and Test Results

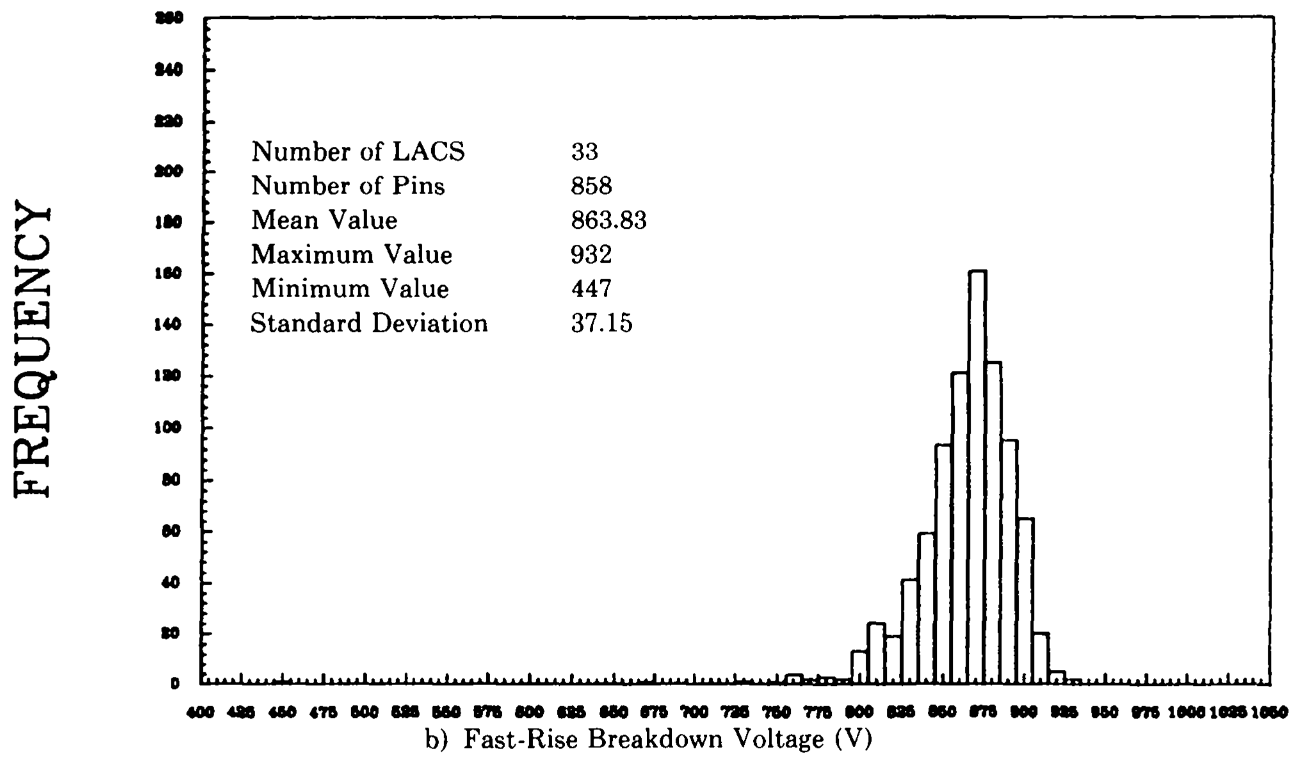
Table 12 shows the BCO and MMSC serial number for each of the 33 connectors processed. A standard 0.010-thick teflon disc was used for the Phase 3 – Group 2 units. No major problems were encountered during processing. MMSC performed the same evaluative testing as they did in Group 1. Figure 17 contains plots of in-process and acceptance (evaluative) FRB test data for the 33 MC4196 LACs. Figure 18 contains a plot of Group 1 and Group 2 FRB test results. There was no significant difference between mixed oxide (Group 1) and chem-prep varistor (Group 2). Tables 13 through 15 summarize the IR testing during processing. A 500 Vdc IR test was performed after each processing sequence prior to filling the pin-to-web gaps with varistor particles (chem-prep) to determine process cleanliness and repeatability. As noted in Table 13, Pin No. 24 of 902-D17-J89 failed the first IR and FRB test during evaluative testing. The analysis of this failure is discussed below under "Failure Analysis (902-D17-J89)."

Table 12. BCO and MMSC Serial Number for Group 2

S/N (MMSC)	S/N (BCO)	S/N (MMSC)	S/N (BCO)
D01	0235	D18	0227
D02	0228	D19	0226
D03	0229	D20	0224
D04	0230	D21	0225
D05	0231	D22	0203
D06	0232	D23	0204
D07	0233	D24	0205
D08	0234	D25	0206
D09	0236	D26	0207
D10	0217	D27	0208
D11	0218	D28	0209
D12	0219	D29	0210
D13	0220	D30	0211
D14	0221	D31	0213
D15	0222	D32	0214
D16	0223	D33	0215
D17	0216		

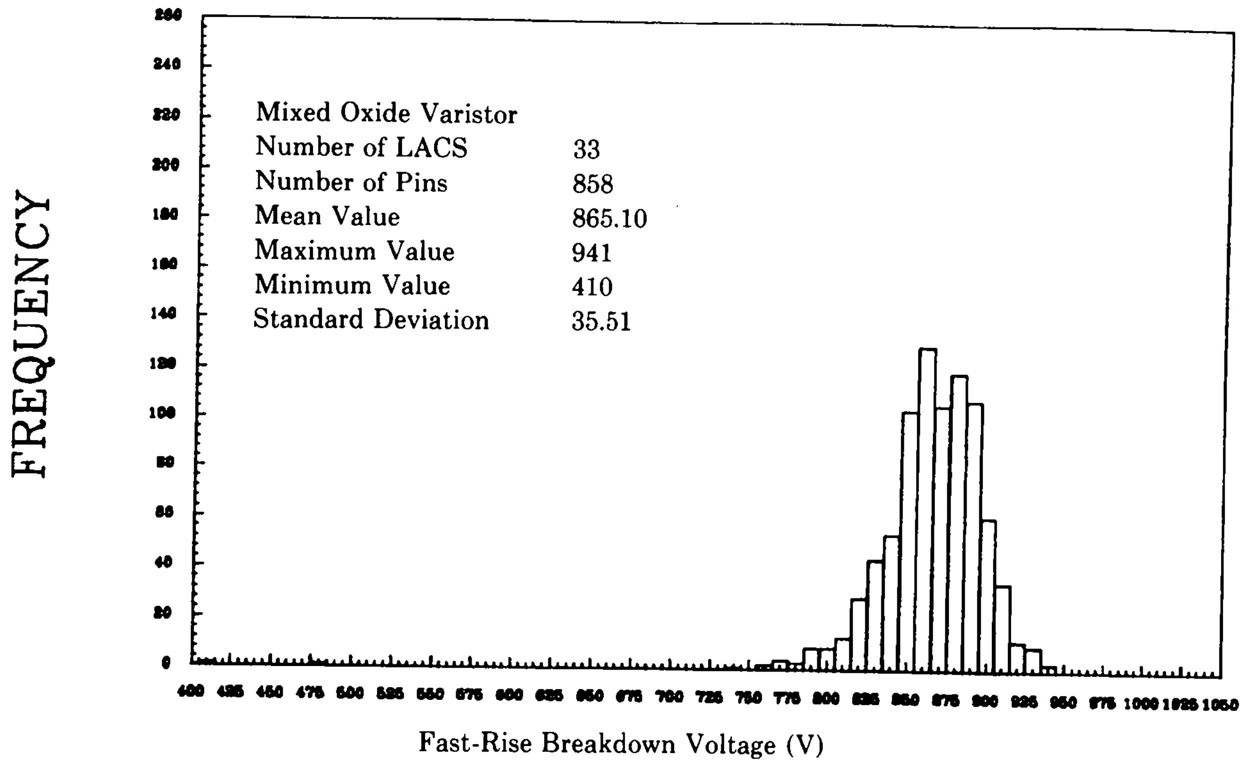


a) Group 2 In-Process

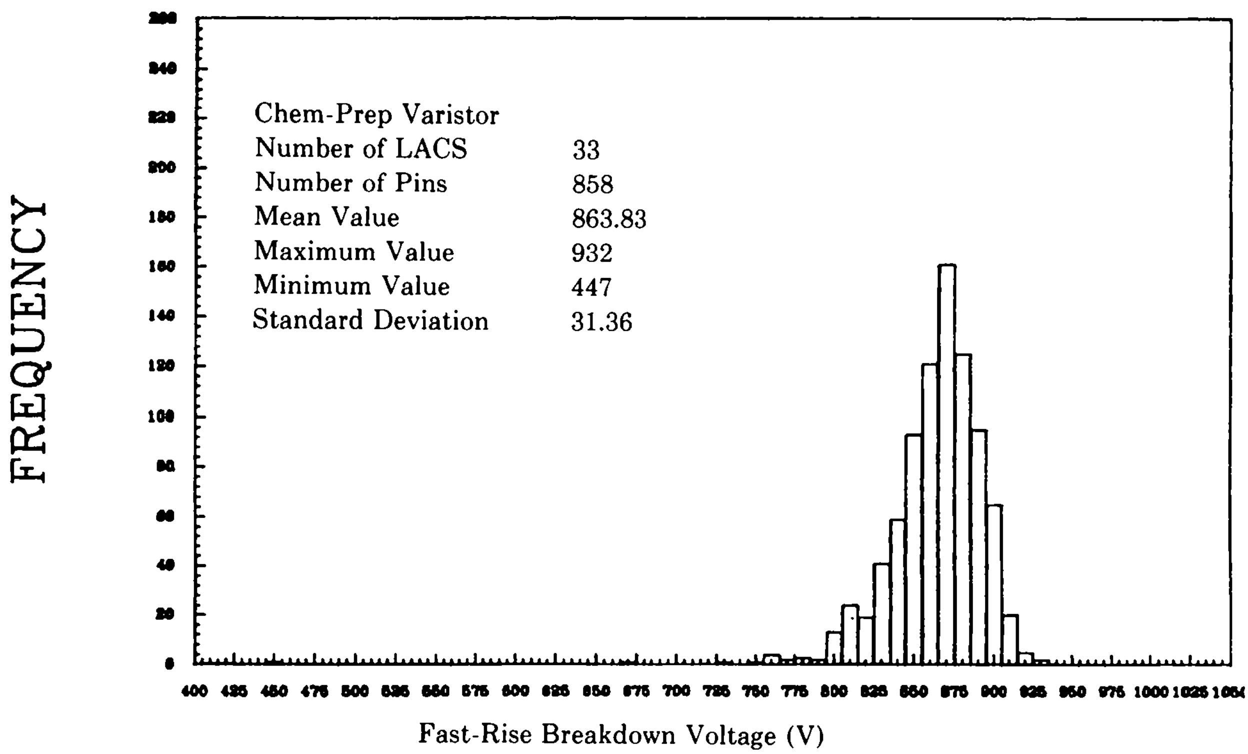


b) Group 2 Acceptance

Figure 17. FRB Test Data (Group 2)



a) Group 1 Mixed Oxide Varistor



b) Group 2 Chem-Prep

Figure 18. FRB Test Data (Groups 1 and 2)

Table 13. In-Process Insulation Resistance

Range: Lower Limit	Range: Upper Limit	Pins Within Range	Pins Below Upper Limit	LACs Within Range	LACs Below Upper Limit
0	4	0	0	0	0
4	7	0	0	0	0
7	10	0	0	0	0
10	40	0	0	0	0
40	70	0	0	0	0
70	100	0	0	0	0
100	400	0	0	0	0
400	700	0	0	0	0
700	1000	0	0	0	0
1000	4000	87	87	22	22
4000	7000	771	858	33	33
7000	10000	0	858	0	33
10000	40000	0	858	0	33
40000	70000	0	858	0	33
70000	100000	0	858	0	33
100000	400000	0	858	0	33
400000	700000	0	858	0	33
700000	1000000	0	858	0	33

MC Type MC4196
Num of LACs = 33
Num of Pins = 858
Mean Value = 4642 Megohms
STD DEV = 501
Max. Value = 6294
Min. Value = 3046

Table 14. Evaluative Insulation Resistance (IR1)

Range: Lower Limit	Range: Upper Limit	Pins Within Range	Pins Below Upper Limit	LACs Within Range	LACs Below Upper Limit
0	4	1	1	1	1
4	7	0	1	0	1
7	10	0	1	0	1
10	40	0	1	0	1
40	70	0	1	0	1
70	100	0	1	0	1
100	400	0	1	0	1
400	700	0	1	0	1
700	1000	3	4	3	4
1000	4000	792	796	33	33
4000	7000	62	858	11	33
7000	10000	0	858	0	33
10000	40000	0	858	0	33
40000	70000	0	858	0	33
70000	100000	0	858	0	33
100000	400000	0	858	0	33
400000	700000	0	858	0	33
700000	1000000	0	858	0	33

MC Type MC4196
Num of LACs = 33
Num of Pins = 858
Mean Value = 3268 Megohms
STD DEV = 574
Max. Value = 4828
Min. Value = 0 Pin No. 24 -902-D17-J89 (Shorted)

Table 15. Evaluative Insulation Resistance (IR2)

Range		Pins	Pins Below	LACs	LACs Below
Lower Limit	Upper Limit	Within Range	Upper Limit	Within Range	Upper Limit
0	4	0	0	0	0
4	7	0	0	0	0
7	10	0	0	0	0
10	40	0	0	0	0
40	70	0	0	0	0
70	100	0	0	0	0
100	400	10	10	7	7
400	700	141	151	31	31
700	1000	635	786	33	33
1000	4000	72	858	21	33
4000	7000	0	858	0	33
7000	10000	0	858	0	33
10000	40000	0	858	0	33
40000	70000	0	858	0	33
70000	100000	0	858	0	33
100000	400000	0	858	0	33
400000	700000	0	858	0	33
700000	1000000	0	858	0	33

MC Type	MC4196
Num of LACs	= 33
Num of Pins	= 858
Mean Value	= 818 Megohms
STD DEV	= 143
Max. Value	= 2011
Min. Value	= 247

7.3.3.1 Environmental Testing

Two units were subjected to environmental tests per the MC4196 development specification (DS412084) at room temperature. No physical damage or electrical failures occurred during the testing. The following units were selected for environmental testing: 962-D07-B89 and 902-D10-J89. Table 16 summarizes the evaluative test results for the two units subjected to D-test.

7.3.3.2 Failure Analysis (902-D17-J89)

The data recorded during evaluative (acceptance) testing suggested a conductive particle of some kind was bridging the pin-to-web gap of Pin 24 during the first IR and subsequent FRB test. After FRB testing, Pin 24 appeared to be normal since it passed the DCWV and final IR testing. The final IR was 2011 megohms, which was the highest IR measurement recorded. An IR measurement of this magnitude after an FRB test, confirms that the particles were not subjected to the test and that some other path of conduction was present during the FRB test on Pin 24. Comparing the measured IR of Pin 24 with the remaining 25 pins supports this assumption. Following evaluative testing, the unit was subjected to particle detection testing at 100 Vdc. No particles were detected during the test. The unit was then retested and passed all evaluative tests. Based on the above analysis and testing, it appears that the conductive path present during initial testing was eliminated during the first FRB test.

7.4 Proof of Development Build

A proof of development build was not initially scheduled as part of the development process. However, when the Group 3 units were fused by BCO, the glass flowed into the contact stress relief area, causing possible glass fracture propagation points. Subsequently, these units were identified as "proof of development build" or processing units for PP evaluations.

7.4.1 Process Development

Thirty units were received and identified as proof of development build (PPs). A Development Quality Program was in place to administer those activities necessary to assure controlled and capable processes are defined prior to process prove-in builds. To

Table 16. Summary of Post-Environmental Electrical Testing (Phase 3 — Group 2)

		Acceptance Testing	After Mech Shock (375 g's)	After Random Vib/Cycling
		902-D07-J89		
*IR1 (125 V)	Max.	3463	4478	2198
	Avg.	2834	3707	1877
	Min.	1366	1587	1116
DCWV		Passed	Passed	Passed
FRB (V)	Max.	903	894	909
	Avg.	876	876	892
	Min.	812	833	827
	Sig.	21	16	17
*IR2 (125 V)	Max.	1021	1009	491
	Avg.	734	821	386
	Min.	470	632	320
		902-D10-J89		
*IR1 (125 V)	Max.	3827	4698	2360
	Avg.	3082	3842	1989
	Min.	1284	1386	1096
DCWV (100 V)	Passed	Passed	Passed	
FRB (V)	Max.	908	907	919
	Avg.	888	882	905
	Min.	864	857	880
	Sig.	12	10	10
*IR2 (125 V)	Max.	985	1019	488
	Avg.	813	858	407
	Min.	536	588	321

*IR Values in Megohms

achieve this goal, the proof of development build was fabricated, inspected and tested as closely as possible to the way WR products would be handled. Most of the action items in the quality program were geared towards preparing for the proof of development build and supported the Department Plan issued by Producibility Engineering.

To accomplish this, Operating Instructions (OIs) were drafted for production use. Once the processes were documented, flow tags were generated and the units forwarded for assembly.

Figure 19 contains a plot of acceptance (evaluative) FRB testing of the 30 units fabricated as the proof of development build. Tables 17 and 18 summarize IR testing.

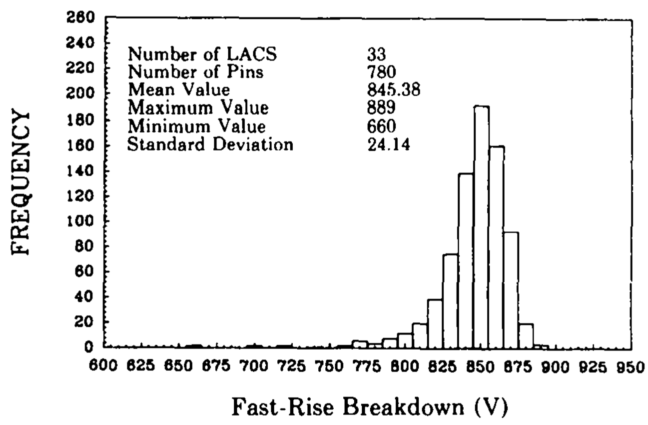


Figure 19. Proof of Development Build FRB Test Data

Table 17. Evaluative Insulation Resistance (IR1)

Range: Lower Limit	Range: Upper Limit	Pins Within Range	Pins Below Upper Limit	LACs Within Range	LACs Below Upper Limit
0	4	0	0	0	0
4	7	0	0	0	0
7	10	0	0	0	0
10	40	0	0	0	0
40	70	0	0	0	0
70	100	0	0	0	0
100	400	2	2	1	1
400	700	14	16	9	9
700	1000	48	64	17	19
1000	4000	716	780	30	30
4000	7000	0	780	0	30
7000	10000	0	780	0	30

MC Type	MC4196
Num of LACs	= 30
Num of Pins	= 780
Mean Value	= 1362 Megohms
Std Dev	= 254
Max. Value	= 2168
Min. Value	= 155

Table 18. Evaluative Insulation Resistance (IR2)

Range: Lower Limit	Range: Upper Limit	Pins Pins Within Range	Below Upper Limit	LACs LACs Within Range	Below Upper Limit
0	4	0	0	0	0
4	7	0	0	0	0
7	10	0	0	0	0
10	40	0	0	0	0
40	70	1	1	1	1
70	100	2	3	2	2
100	400	757	760	30	30
400	700	20	780	7	30
700	1000	0	780	0	30
1000	4000	0	780	0	30
4000	7000	0	780	0	30
7000	10000	0	780	0	30

MC Type	MC4196
Num of LACs	= 30
Num of Pins	= 780
Mean Value	= 306 Megohms
Std Dev	= 52
Max. Value	= 458
Min. Value	= 58

7.4.2 Proof of Development Build Evaluation

Groups 1 and 2 from the Development Builds were subjected to environmental testing at room temperature only. Environmental testing of Group 3 units was also planned to be performed at room temperature. In order to determine the performance of the MC4196 LAC in SRAMII environments, 16 units were randomly selected from the Proof of Development Build and evaluated at low (−55°C) and high (+85°C) temperatures. Appendix D details the evaluation parameters and identifies the test samples.

Tables 19, 20, and 21 summarize the environmental test results. Table 22 summarizes insulation resistance testing before and after thermal cycling. Precycling FRB data is also included in Table 22 for reference. Figure 20 contains the thermal cycling profile for the 16 units selected. Figure 21 contains plots of the results compiled on three of the units identified in Table 21. Figure 22 is a plot of average FRB vs temperature. Appendix E has a producibility assessment summary based on the Proof of Development Build.

Table 19. Mechanical Shock Testing (+X, +Z, and −Z Directions)

+94°C	903-DO1-H90		903-D08-H90		903-D17-H90		903-D23-H90	
Average	IR	FRB	IR	FRB	IR	FRB	IR	FRB
Baseline	1840	854	1616	836	1016	846	1513	838
After 375 g 6.0 ms	376		272		101		152	
After 475 g 6.0 ms	168		128		42		66	
After 575 g 6.0 ms	131	848	109	828	49	846	55	834
−55°C	903-DO4-H90		903-D07-H90		903-D10-H90		903-D13-H90	
Average	IR	FRB	IR	FRB	IR	FRB	IR	FRB
Baseline	1728	866	1282	857	1496	843	1022	834
After 375 g 6.0 ms	1726		1368		1626		1184	
After 475 g 6.0 ms	1691		1333		1532		1166	
After 575 g 6.0 ms	1632	872	1388	869	1613	851	1276	842

Table 20. Random Vibration (X and Z Direction −30 Minutes Each Direction)

+85°C	903-D09-H90		903-D11-H90		903-D12-H90		903-D15-H90	
Average	IR	FRB	IR	FRB	IR	FRB	IR	FRB
Baseline	1357	847	1529	843	1393	855	1781	858
2000 .67 g^2 Hz (X and Z)	117	874	293	864	132	870	178	881
2000 1.0 g^2 Hz (X and Z)	640	861	240	867	180	860	256	873
−55°C	903-D03-H90		903-D05-H90		903-D06-H90		903-D27-H90	
Average	IR	FRB	IR	FRB	IR	FRB	IR	FRB
Baseline	1466	834	1591	836	1533	841	1270	844
2000 .67 g^2 Hz (X and Z)	1631	855	1702	864	2012	869	1692	869
2000 1.0 g^2 Hz (X and Z)	1783	862	1404	852	1719	867	1525	871

Table 21. MC4196 Thermal Cycling (Average IR in Megohms/IR Performed at 125 V)

Cycle #	D01	*D03	*D04	D05	D06	D07	*D08 **	D09	*D10	*D11	D12	D13	*D15 **	D17	*D23 **	*D27
0	131	1783	1632	1404	1719	1388	109	64	1613	240	180	1276	256	49	55	1525
8		1010	672				91		455	344			323		49	766
16		878	544				73		307	318			303		44	865
24		775	427				53		204	292			285		36	730
32		666	341				42		149	264			254		31	672
40		670	292				34		117	244			237		26	694
48		553	276				26		89	242			230		22	654
56		580	230				21		73	263			253		19	657
64		594	217				16		96	247			252		28	640
72		532	187				21		98	238			219		36	587
80		557	172				42		98	211			238		40	636
88		540	162				51		91	236			231		41	617
96		493	137				53		83	214			201		40	572
104		520	132				57		81	230			229		40	595
112	80	478	123	386	705	19	57	181	80	224	166	99	206	26	40	578

*D03, D04, D08, D10, D11, D15, D23, and D27 were tested during cycling
**Data Plotted In Figure 21 Lower Limit for IR = 2 Megohms

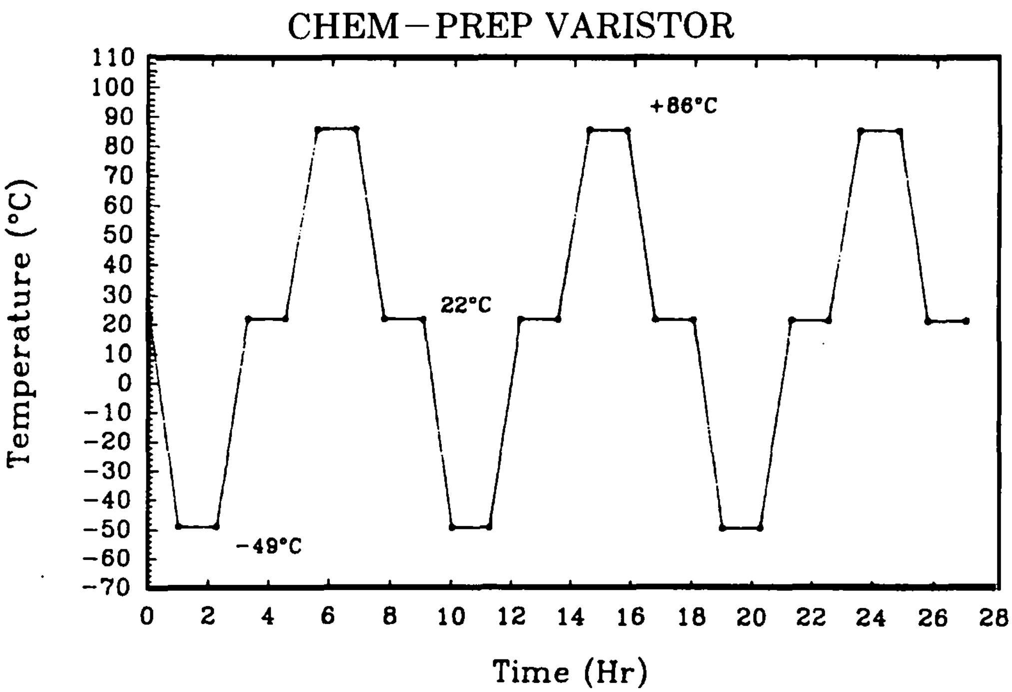


Figure 20. Proof of Development Build Thermal Cycling Profile

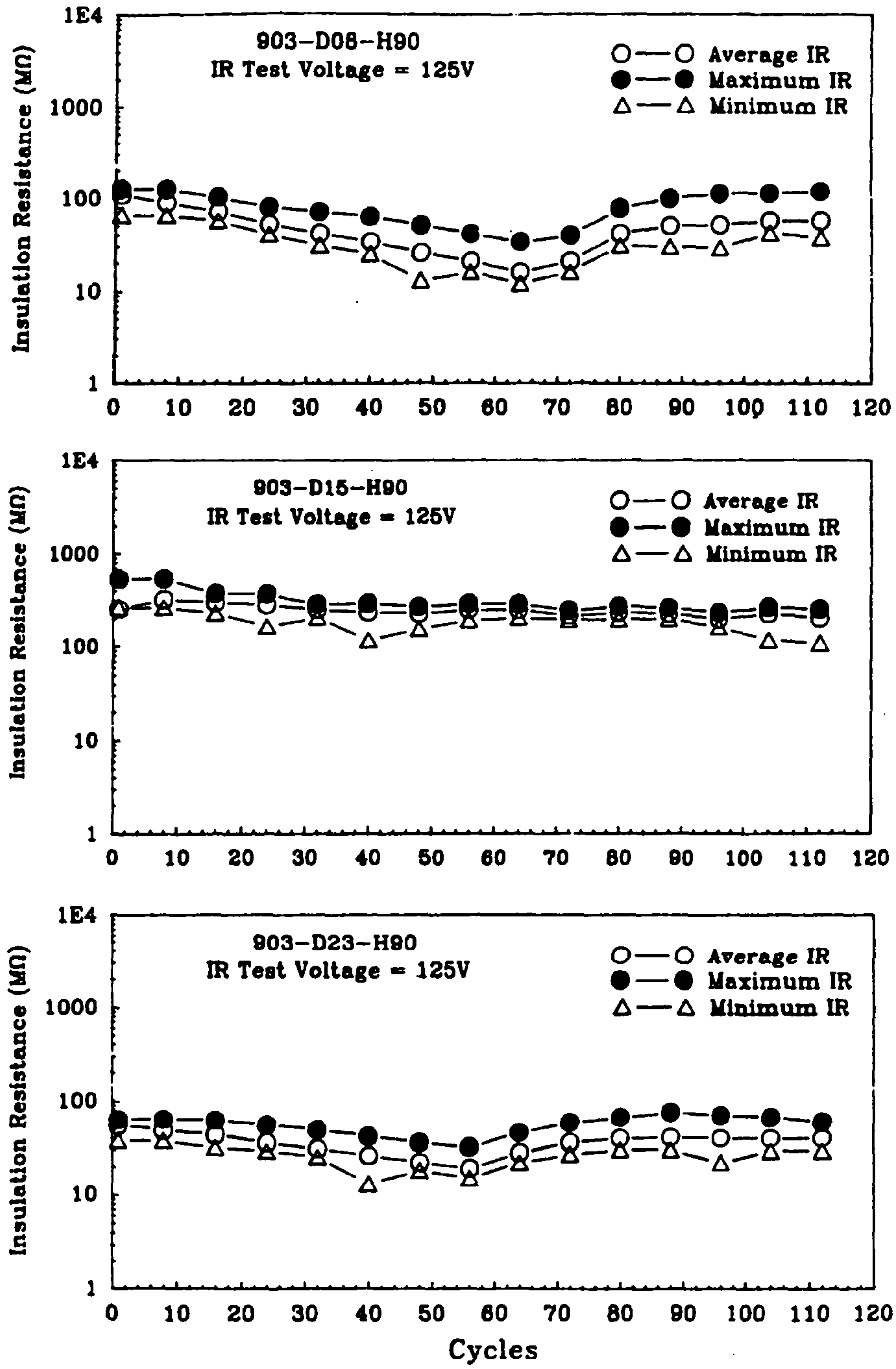


Figure 21. Proof of Development Build Thermal Cycling/Average IR Plots

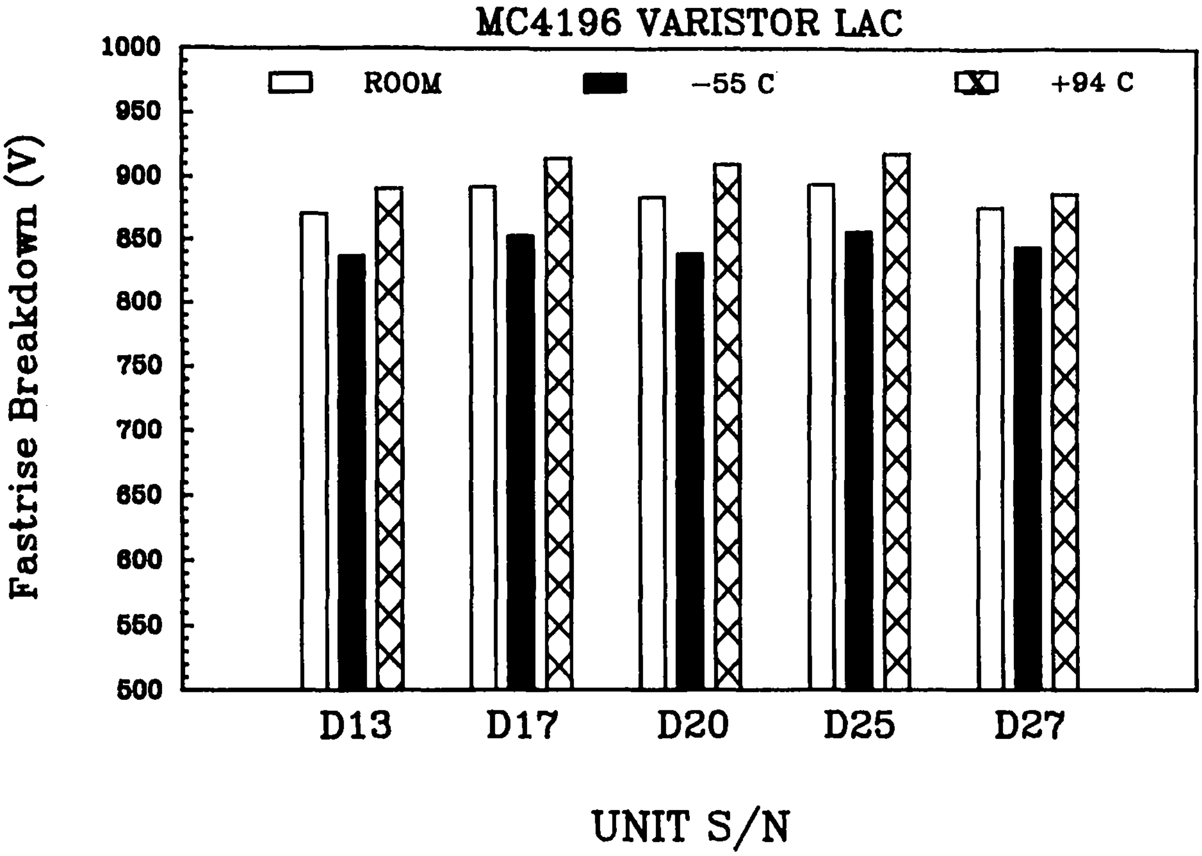


Figure 22. Proof of Development Build Evaluation of Average FRB vs Temperature

7.5 Phase 4 — Group 3 MC4196 Fabrication and Test Results

Due to problems with the connector processing at BCO, Group 3 connectors exhibited IR problems. Therefore two lots of 19 each were supplied to MMSC. Although the units were acceptable per the product specification, the IR was significantly lower than Groups 1 and 2 connectors.

There were no significant processing changes incorporated between Group 2 and Group 3 connectors. Figure 23 contains plots of in-process and acceptance FRB testing. This figure summarizes the first 19 units assembled; Figure 24 summarizes the second group of 19 units. Table 23 summarizes the IR testing of all 38 units, then summarizes the first and second build of 19 units. Tables 24, 25, and 26 summarize the testing as one lot of 38 units.

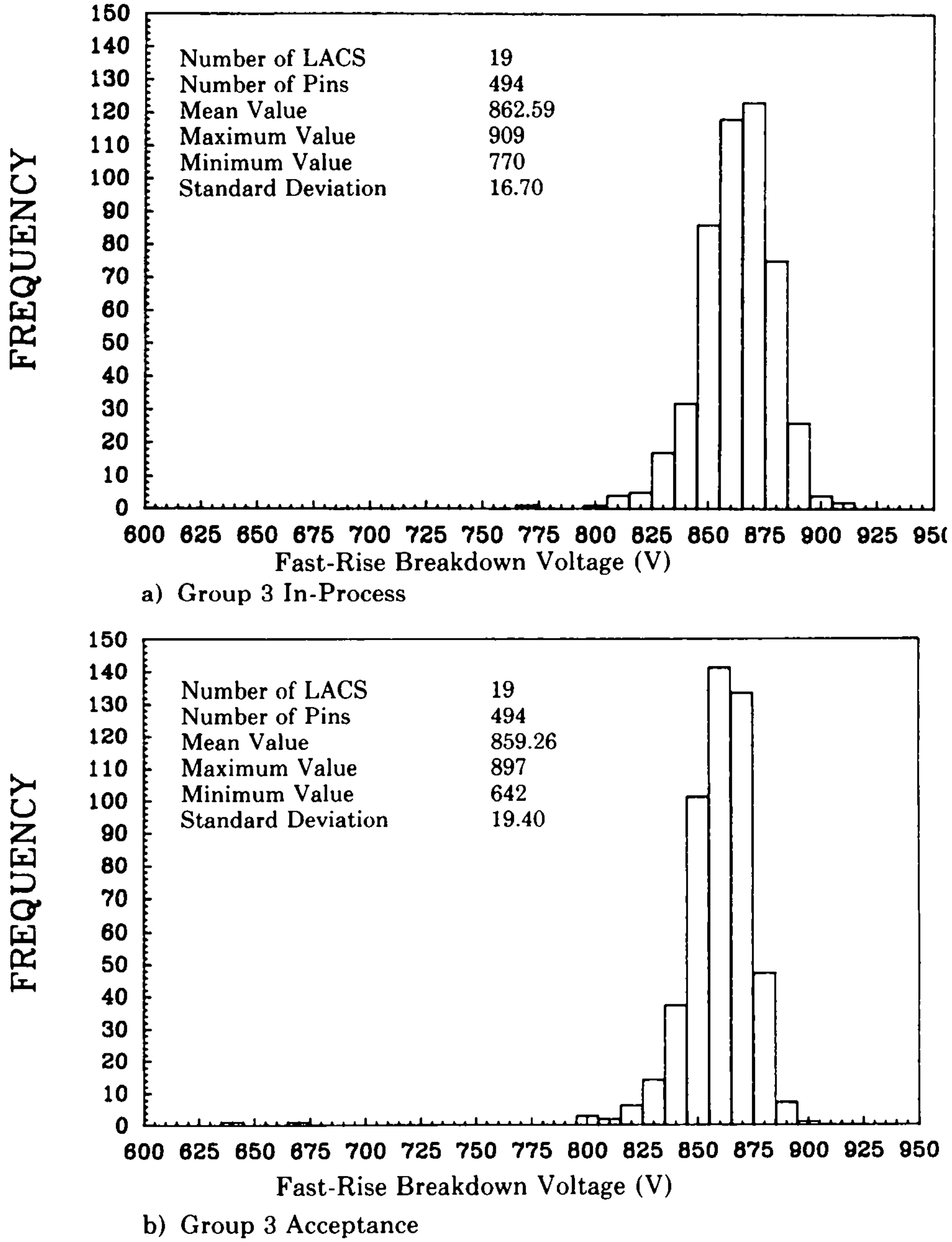
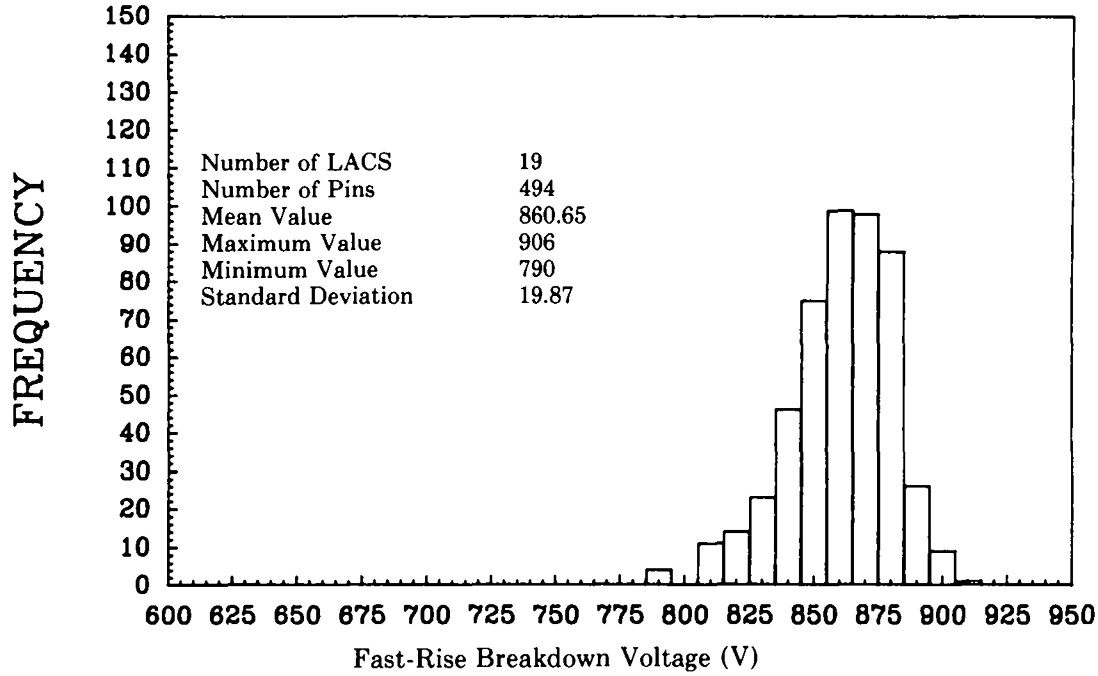
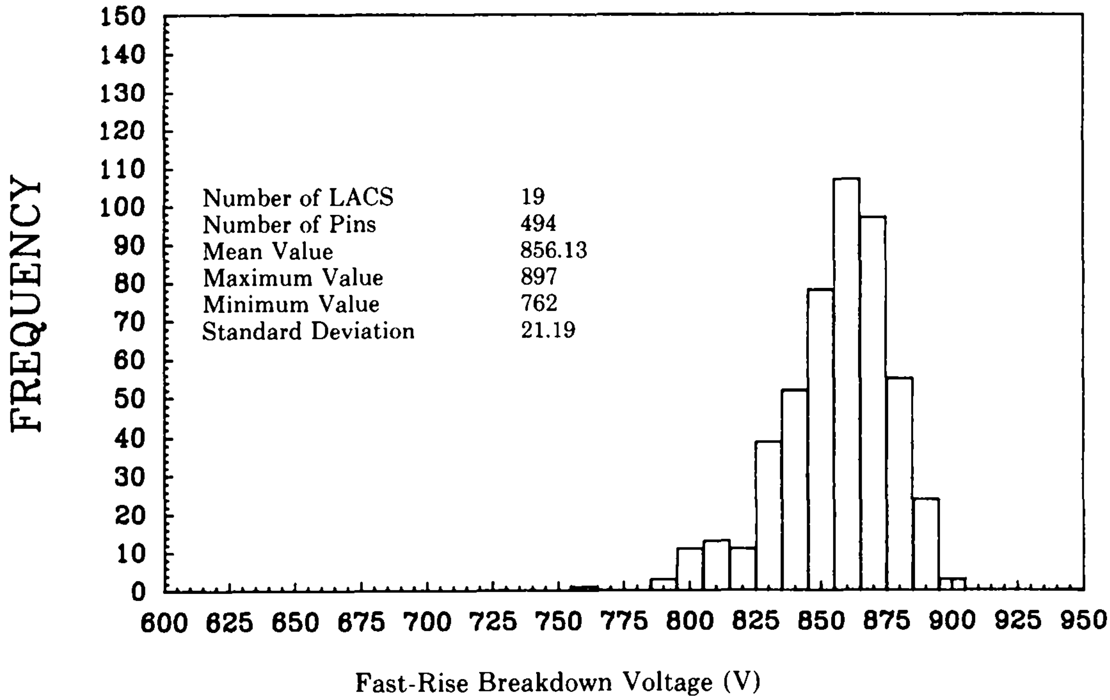


Figure 23. FRB Test Data (Group 3: First 19 units)



a) Group 3 In-Process



b) Group 3 Acceptance

Figure 24. FRB Test Data (Group 3: Second 19 units)

Table 22. IR at 125 V/ FRB/IR at 50 V Before and After Thermal Cycling

	D01	D03	D04	D05	D06	D07	D08	D09	D10	D11	D12	D13	D15	D17	D23	D27
IR at 125 V Before Thermal Cycling																
Max.	195	1983	1929	1622	2154	1877	136	–	1899	431	266	1605	335	89	74	2012
Avg.	131	1783	1632	1404	1719	1388	109	–	1613	240	180	1276	256	49	56	1524
Min.	100	1511	693	576	473	584	71	–	502	96	15	496	150	38	40	356
FRB Before Thermal Cycling																
Max.	862	895	891	884	894	894	873	891	877	887	886	876	897	866	857	897
Avg.	848	862	872	852	867	869	828	861	851	867	860	842	873	846	834	871
Min.	809	827	852	797	803	818	685	815	785	825	791	726	837	822	776	815
Sig.	10	21	10	23	23	19	41	18	23	16	23	31	13	13	17	25
IR at 50 V After FRB Testing																
Max.	204	354	1063	331	347	1054	153	118*	1076	53*	34*	962	29	95	73	388*
Avg.	135	285	892	272	284	886	117	64*	922	30*	21*	807	26	55	61	258*
Min.	104	236	776	212	159	723	93	34*	593	20*	10*	369	23	43	48	121*
IR at 125 V After Thermal Cycling																
Max.	194	613	221	469	1360	39	117	237	164	324	236	148	255	44	60	713
Avg.	80	478	123	386	705	19	57	181	80	224	166	99	206	26	40	578
Min.	46	335	80	233	257	12	37	88	55	117	32	60	110	21	29	111
FRB After Thermal Cycling																
Max.	881	899	878	886	899	868	878	894	881	903	903	874	909	866	873	894
Avg.	855	861	862	858	873	848	842	874	850	882	877	832	886	846	849	875
Min.	817	804	846	818	818	798	728	849	805	854	808	717	867	817	788	829
Sig.	14	25	10	19	22	15	35	11	17	12	23	29	10	13	17	17
IR at 50 V After FRB Testing																
Max.	906	4987	947	5274	5194	153	501	12328	681	12088	15991	738	14881	200	295	10249
Avg.	413	3537	590	3052	5194	88	305	3749	366	4435	5228	514	6760	135	201	5968
Min.	170	2523	219	933	452	62	120	209	256	500	65	317	2690	92	145	222

*IR Performed at 125 V

Table 23. Summary of Insulation Resistance Testing (Phase 4 — Group 3)

Number of LACs = 38
Number of Pins = 988

	Insulation Resistance (IR) @ 125 V (Megohms)		
	IR1	IR2	
Max.	1768	407	
Avg.	946	229	
Min.	123	4	2 Megohm Lower Limit
	First 19 Units Number of Contacts = 494		
Max.	1768	358	
Avg.	1109	244	
Min.	140	4	
	Second 19 Units Number of Contacts = 494		
Max.	1527	407	
Avg.	784	213	
Min.	123	53	

Table 24. In-Process Insulation Resistance

Range Lower Limit	Range Upper Limit	Pins Within Range	Pins Below Upper Limit	LACs Within Range	LACs Below Upper Limit
0	4	0	0	0	0
4	7	0	0	0	0
7	10	0	0	0	0
10	40	0	0	0	0
40	70	0	0	0	0
70	100	0	0	0	0
100	400	0	0	0	0
400	700	14	14	3	3
700	1000	146	160	25	25
1000	4000	828	988	38	38
4000	7000	0	988	0	38
7000	10000	0	988	0	38

MC Type	MC4196
Num of LACs	= 38
Num of Pins	= 988
Mean Value	= 1262 Megohms
Std Dev	= 252
Max. Value	= 1893
Min. Value	= 571

Table 25. Evaluative Insulation Resistance (IR1)

Range: Lower Limit	Range: Upper Limit	Pins Within Range	Pins Below Upper Limit	LACs Within Range	LACs Below Upper Limit
0	4	0	0	0	0
4	7	0	0	0	0
7	10	0	0	0	0
10	40	0	0	0	0
40	70	0	0	0	0
70	100	0	0	0	0
100	400	139	139	22	22
400	700	156	295	32	33
700	1000	125	420	31	37
1000	4000	568	988	29	38
4000	7000	0	988	0	38
7000	10000	0	988	0	38

MC Type	MC4196
Num of LACs	= 38
Num of Pins	= 988
Mean Value	= 946 Megohms
Std Dev	= 387
Max. Value	= 1768
Min. Value	= 123

Table 26. Evaluative Insulation Resistance (IR2)

Range: Lower Limit	Range: Upper Limit	Pins Within Range	Pins Below Upper Limit	LACs Within Range	LACs Below Upper Limit
0	4	0	0	0	0
4	7	1	1	1	1
7	10	0	1	0	1
10	40	0	1	0	1
40	70	13	14	6	7
70	100	45	59	14	0
100	400	928	987	38	22
400	700	1	988	1	33
700	1000	0	988	0	37
1000	4000	0	988	0	38
4000	7000	0	988	0	38
7000	10000	0	988	0	38

MC Type	MC4196
Num of LACs	= 38
Num of Pins	= 988
Mean Value	= 229 Megohms
Std Dev	= 71
Max. Value	= 407
Min. Value	= 4

8. SA3581 PPI Activities at BCO—A Follow-Up

After correcting processing problems, implementing, training, and documenting operating instructions at BCO, identified in Group 3, BCO began several starts on the PPI order. PPI Lot 1 was observed by the QS team and rejected at BCO's first inspection due to poor workmanship.

A total of 23 of the 50 units were rejected for:

- three connectors had upside down pins
- six connectors had pins under deck height caused by second fusing run in the furnace to seal the "see throughs"
- one connector had pins bent like an "S," cause unknown
- one connector had a bent connector tab
- six connectors had gold plating migration across glass to adjacent pin
- four connectors had bent pins
- two connectors had pins with glass cracks.

BCO started 60 units of PPI Lot 2 and yielded 44 units. Sixteen units were rejected for insulation resistance and laser weld burn throughs. The remaining 44 units were received at MMSC's Incoming Test and Inspection packaged in a single box and exhibited damaged threads from transportation. Eighteen of the 44 units were subsequently rejected for insulation resistance.

A ten-unit matrix was constructed to evaluate the following improvements: connector ID enlarged in glass fuse zone, carbon pressor pad diameter increased and added chambers, new stainless-steel weights, new fusing fixtures constructed, and glass preforms modified by the addition of a wetting lip, larger diameter, smaller ID holes and increased glass volume.

PPI Lot 3 units were rejected for laser weld burn through on the hood and interface gage problems. A fifteen unit build was constructed with new glass preforms and new laser weld tooling and acceptable results were obtained.

PPI Lot 4 was halted because BCO changed the pin diameter drawing without obtaining MMSC approval. The latest glass preforms received were evidently sintered by mistake just prior to use at BCO which eliminated necessary tolerances for fusing fixture assembly. To continue production and utilize the preforms, BCO reduced the pin diameter in the glass fuse zone. These assemblies will not be representative of WR production and do not satisfy the purpose of a PPI build. Therefore, to ensure repeatability, piece parts will be replaced with the approved definition and PPI Lot 4 will be reprocessed under strict monitoring by SNL and MMSC engineers.

9. Alternate Source Proposal

An alternate source proposal was presented to the W89 Systems Group on September 12, 1991 because of problems encountered at BCO on the SA3581 connector. Problems identified during development were resolved with SNL/MMSC input in the areas of glass fusing, fixtures, welding, and material selections. However, during PPI production, BCO treated this very unique design with the same effort it gives commercial products. Thus, development units did not perform as planned and final development schedules to MMSC were repeatedly delayed. The following information (Appendix E) presents the process for finding and training a new supplier.

10. Conclusions

Extensive testing has proven that the MC4196 lightning arrestor connector meets or surpasses all design requirements for the W89 system. MMSC successfully developed the new processes and varistor material needed to fabricate the MC4196 LAC in an engineering and production facility environment. This technology has been transferred to the MMSC WR production area for proof of development build.

All testers and gages have been assessed and are on-line for WR evaluation. The lessons learned have been difficult ones, but have brought MMSC and Sandia experts together. These experts have worked with Amphenol-BCO in the areas of glass fuzing, material compatibility, fixturing, manufacturability, document control, processing, assembly, testing, and gaging procedures in an effort to maintain the SA3581 LAC subassembly integrity at BCO. It is the consensus of the MC4196 LAC team that whenever possible Sandia needs to define the complete product definition for integral subassemblies, such as the SA3581.

When modified commercial designs prohibit this approach, a system for monitoring (such as an audit trail or continuous on-site review) must be considered as part of the acceptance criteria. This criteria should be used in the procurement and development processes as part of the Purchase Order Agreement that determines what supplier will be selected. Technology transfer cannot stand alone; it must be accompanied by strict performance methods as a metrics.

Bibliography

Reports

B. A. Tuttle, J. A. Voight and L. A. Andrews, *The First Synthesis of Chem-Prep Varistor LAC Granules*, SAND87-3112, Sandia National Laboratories, Albuquerque, NM, January 1988.

W. Washington, Largo, FL: *MC4078 Fast-Rise Breakdown Testing*, MMSC, June 20, 1989 Engineering Section Technical Letter Report 90-LAC-2.

D. Goy and W. Washington, *Chemically Prepared Varistor for Lightning Arrestor Connector Application - Final Report*, MMSC, GEPP-FR-1154, August 30, 1989.

W. Washington, *MC4196 Development Report Phase 2-Group 1*, Largo, FL: MMSC, September 22, 1989 (U), Development Report.

J. A. Barnum and R. J. Fisher, *Preliminary MC4078 Connector Electrostatic Discharge (ESD) Response Characterization*, SNL R#002, February 12, 1990.

R. Selfridge, *Development SA3581 Group II Destructive "D" Testing as per Sandia Specification DS411799, Issue "C" (Sidney, N.Y.*, Bendix Connector Operations), April 3, 1990, Engineering Report No. 8240.

W. Washington *MC4196 Development Report Group 2*, Largo, FL: Pinellas Plant, July 1, 1990, Engineering Section Technical Letter Report 90-LAC-3 (U).

Memorandums

D. E. Carnicom, 2544, *MC4078 LAC (W89) Conceptual Design Review Action Items* (Albuquerque, NM: Sandia National Laboratories), June 22, 1988 Memorandum (U).

J. B. Neale, *MC4078 LAC - Mission Assignment*, Largo, FL: MMSC, November 14, 1988, Memorandum.

D. L. Armour, 2551, *Proposed Policy for Gaging the MC4078* (Albuquerque, NM: Sandia National Laboratories), August 25, 1989, Memorandum.

D. L. Armour, 2551, *Production Quality Goals for the MC4078* (Albuquerque, NM: Sandia National Laboratories), October 25, 1989, Memorandum.

D. L. Armour, 2551, *PS411447 for the SA3581/JT Connector* (Albuquerque, NM: Sandia National Laboratories), November 16, 1989, Memorandum.

D. E. Carnicom, 2551 *Minutes of the MC4078 Prototype Design Review* (Albuquerque, NM: Sandia National Laboratories), December 13, 1989, Memorandum.

D. L. Armour, 2551, *MC4078 Material Compatibility* (Albuquerque, NM: Sandia National Laboratories), December 20, 1989, Memorandum.

D. E. Carnicom, 2551, *Production FRTVB Testing of the MC4078 and CF 2904* (Albuquerque, NM: Sandia National Laboratories), January 11, 1990, Memorandum.

Nancy Dhooge, 1823, *Combined Material Assessment of the LAC* (MC4078) (Albuquerque, NM: Sandia National Laboratories), February 14, 1990, Memorandum.

D. L. Armour, 2551, *MC4078 Review Meeting* (Albuquerque, NM: Sandia National Laboratories), May 1, 1990, Memorandum.

D. L. Armour, 2551, *Operator Training* (Albuquerque, NM: Sandia National Laboratories), June 14, 1990, Memorandum.

D. L. Armour, 2551, *Minutes of the MC4078 Status Review Meeting* (Albuquerque, NM: Sandia National Laboratories), June 22, 1990, Memorandum.

G. J. Roubik, *MC4196 LAC/SA3581 Connector Tester/Adapter Requirements/Maintenance*, Largo, FL: MMSC, August 9, 1990, Memorandum.

G. J. Roubik, *MC4196 LAC/SA3581 Connector Tester/Adapter Requirements/Maintenance*, Largo, FL: MMSC, August 27, 1990, Memorandum.

G. J. Gabert *W89 Systems Proposal to Modify SA3581 Connector*, Largo, FL, MMSC, September 10, 1990, Memorandum.

R. Selfridge, *Group III IR Problems* (Sidney, NY: Bendix Connector Operations), September 24, 1990, Memorandum.

J. B. Wright, *MC4078 LAC Design Change* (Livermore, CA, Sandia National Laboratories), October 9, 1990, Memorandum.

R. D. Sauls, 8155, *MC4078 LAC Shell Torque Test Results* (Livermore, CA: Sandia National Laboratories), October 23, 1990, Memorandum.

R. Selfridge, *Glass Problem Solutions* (Sidney, NY: Bendix Connector Operations), October 31, 1990, Memorandum.

R. Selfridge, *Glass Sealing Experimental Results* (Sidney, NY: Bendix Connector Operations), December 4, 1990, Memorandum.

G. J. Roubik, *MC4196 LAC Heated Encapsulation Process Review Report*, Largo, FL: MMSC, February 22, 1991, Memorandum.

G. J. Roubik, *MC4196 LAC Laser Weld of WEB Process Review*, Largo, FL: MMSC, February 22, 1991, Memorandum.

G. J. Gabert, *SA3581 Connector Operations at BCO*, Largo, FL, MMSC, September 10, 1991, Memorandum.

G. J. Gabert, *SA3581 Connector Operations at BCO*, Largo, FL, MMSC, September 26, 1991, Memorandum.

Program Review Meetings

LAC Program Review at SNLA, June 8, 1988, SAND88-2889

LAC Program Review at MMSC, November 29, 1988

LAC Program Review at SNLA, July 25, 1989, SAND89-2643

LAC Program Review at MMSC, March 13, 1990

LAC Program Review at SNLA, July 25, 1990

LAC Program Review at MMSC, February 1991

LAC Program Review at SNLA, July 25, 1991

Component Design Review Meetings

MC4078 Robust Design Review at MMSC, May 26, 1988

MC4078 LAC Conceptual Review Meeting at Sandia, June 7, 1988

MC4078 Prototype Design Review at Sandia, Nov. 7, 1989

MC4078 Status Review at BCO, June 6, 1990

MC4078 Interagency Design Review at BCO, April 16-17, 1991

APPENDIX A

Laser Welding - SA3581 Metal Hood at BCO

CONTENTS

LASER WELDING OF 10-567146-26S HOODED LAC CONNECTOR

1.0 SCOPE:

This specification defines the requirements for laser beam welding of the SA3581 LJT-LAC Connector to assure satisfactory weld quality. This specification applies to the autogenous weld which joins the BCO 10-567146-26S type hooded LJT-LAC receptacle connector.

2.0 APPLICABLE DOCUMENTS:

The following documents of the latest issue in effect form a part of this specification to the extent specified herein:

Amphenol/BCO Specification:

9-4187 Welding (Other Than By Resistance Heating Quality Requirements and Interpretation)
9-8987 Laser Welding of 10-567150-26S LAC/Filter Connector

American Welding Society Standards:

AWS A3.0 Welding Terms and Definitions

3.0 TECHNICAL REQUIREMENTS:

3.1 Definitions:

3.1.1 Welding Operator: A person capable of producing acceptable weldments using the laser welding process, and who has been qualified per this specification.

3.1.2 Weld Schedule: A particular procedure, including specific machine settings, which have been established as satisfying the requirements of this specification.

3.1.3 Qualification: A test to demonstrate the technical proficiency and machine knowledge of the laser beam welding machine operators.

3.1.4 Machine Journal: A record or log indicating all machine activities, machine maintenance activities and equipment performance. The Materials Laboratory shall be responsible for maintaining this machine journal.

3.1.5 Shine Through: Shine through exists when the laser beam has penetrated a gap and visually marked a surface other than the gap surfaces.

3.1.6 Welding Terms: Welding terms and definitions shall be found in AWS A3.0-85, 9-4187 welding process specification, and BCO Welding Manual, except as follows:

Porosity-approximately spherical-shaped voids in the metal.

3.2 Welding Equipment: Welds produced to this standard shall be made by a machine which produces a weld by heating with coherent light energy.

3.2.1 Equipment Certification: Repeatability verification of laser equipment and rotational tooling shall be the responsibility of Quality Control, Instrument Calibration Group. Intervals between certification of laser pulse frequency and rotational fixture speed shall not exceed 6 months. Intervals between certification of power meter shall not exceed 1 year.

3.2.1.1 Equipment Certification Requirements: The following items on each laser beam welder shall be repeatable to an accuracy as follows:

a. Watt Meter: $\pm$ 12% of the indicated power setting

b. Rotational Fixture Speed Control: $\pm$ 3%

c. Laser Pulse Frequency: $\pm$10%

3.2.1.2 Records: A record of all certifications of laser beam welding machine and accessories shall be kept in machine journals.

3.2.2 Equipment Maintenance: The laser shall be maintained in accordance with the Metallurgical Laboratory Procedure M-11.

3.2.2.1 Records: A record of all maintenance activities on the laser welding machine and accessories shall be kept in the machine journal.

3.3 Process Requirements: Unless otherwise stated within this specification, all welds shall be made in accordance with 9-4187.

3.3.1 Part Cleanliness: Parts to be welded shall be free from oil, grease, foreign particles or other contaminants that are detrimental to weld quality.

3.3.2 Operator Qualification/Requalification: Production laser beam welding shall be performed only by operators qualified to 9-4187 and this specification using certified, functionally approved equipment and certified weld schedules as defined by this specification.

3.3.2.1 Qualification: Laser production welding operators shall be qualified and requalified by satisfactorily performing qualification tests. Qualification must be established through verification of weld results on test specimens made per 3.3.4, unless previously qualified per 9-8987. Qualification must be accomplished on the machine to be used for production welds.

3.3.2.2 The weld schedules for the operators' qualification test shall be the ones made per 3.3.3 and approved by the Materials Laboratory welding engineer. Operator qualification samples may be used to qualify the weld schedule.

3.3.2.3 Requalification Intervals: The operator shall be requalified when there is evidence of unsatisfactory performance of the operator.

3.3.2.4 Records: Records indicating welding operators' qualification and requalification shall be maintained at the weld station in the Laser Processing Area.

3.3.3 Weld Schedules: A weld schedule shall be established for each weld joint design before weld joints of that design are welded in production or in operator qualification. Changes shall not be permitted to specific weld schedules without the approval of the responsible Engineering welding engineer and certification of the changes schedule. The weld schedule shall contain a complete identification of machine settings, tooling, material combinations and certification date.

3.3.3.1 Certification of Schedule: Test specimens per 3.3.4 shall be welded and metallurgically inspected to certify the weld schedule on the laser beam welder.

3.3.3.2 Recertification of Weld Schedule: If the welding machine has been significantly changed due to maintenance or malfunction, the existing weld schedules must be recertified using test specimens per 3.3.4.

3.3.3.3 Special Requirements: Tack welding may be used only as specified on the weld schedule.

3.3.3.4 Records: Records indicating weld schedule certification and recertification shall be maintained at the weld station in the Laser Processing Area.

3.3.4 Certification/Qualification Test Specimens: The number of test specimens required for the test activities shall be as indicated in Table 1. Test specimen types consist of a functional bead on plate and a joint configuration.

3.3.4.1 Joint Configuration: A joint configuration can be a representative sample or an actual production definition part; either of which must be of the proper material and specific dimension in the weld joint area.

3.3.4.2 The test specimens shall be welded according to the weld schedule. The schedule shall not be changed and maintenance shall not be performed on the welding equipment while welding the test specimens.

3.3.4.3 All test specimens shall conform to quality assurance provisions of Section 4.

3.3.4.4 Each test specimen shall be identified as to the welding operator, weld schedule and date of test performed.

3.3.4.5 Test specimen data pertinent to the weld requirements shall be obtained and maintained as required per this specification.

TABLE 1

TYPE OF TEST	MINIMUM SAMPLE QTY. BEAD ON PLATE	MINIMUM SAMPLE QTY. JOINT CONFIGURATION	FREQUENCY	PARAGRAPHS	REMARKS
Weld Schedule Certification	1	2	Original	3.3.3.1	
Weld Schedule Recertification	1	2	(See Note 1)	3.3.3.2	
Operator Qualification	1	2	Original	3.3.2	(See Note 3)
Operator Requalification	1	1	(Note 2)	3.3.2.3	

NOTES:
1. Following maintenance or malfunction if the welding machine has been significantly changed.
2. When there is evidence of unsatisfactory performance of the operator.
3. Operators qualified per 9-8987 meet the requirements for qualification.

3.3.5 Repair of Defects: Repair of defects is permissible, if the repaired weldment, the repaired weld itself and the adjacent parent metal meet the requirements of the original weldment. One attempt to repair the defect can be made with the laser after a cool down period of 10 minutes from making the original weld. Prior to rewelding, the weld fusion zone and adjacent parent metal shall be stainless steel, wire brushed to remove oxides.

4.0 QUALITY ASSURANCE PROVISIONS:

4.1 Weld criteria shall be as follows:

4.1.1 Weld penetration shall be 0.010 inch minimum and 0.016 inch maximum.

4.1.2 Surface cracks in the weld metal are unacceptable.

4.1.3 Weld shall be 80% of the circumferential weld distance. Individual and randomly dispersed holes in the fusion zone are acceptable as long as they do not exceed 20% of circumferential weld distance.

4.1.4 Weld splatter is permissible provided it is not on any connector mating surface.

4.1.5 Weld craters are acceptable as long as the bottom of the hole reveals visible fusion with no joint separation.

4.1.6 Any internal weld inclusion or porosity which has a length greater than 1/4 of the measured penetration shall be unacceptable.

4.2 Inspection:

4.2.1 All weld joints shall be 100% inspected for weld surface defects at 10X-30X per Paragraphs 4.1.2-4.1.5.

4.2.1.1 Rejected welds shall be sent to MRB.

4.2.2 All test specimens for weld schedule certification (3.3.3.1 and 3.3.3.2) and operator qualification (3.3.2.1 and 3.3.2.3) shall be cross-sectioned and 100% metallurgically inspected at 50X minimum. Cross sections shall be photographed, documented in an Engineering Report and retained by the Engineering Materials Lab and Quality Control.

4.2.2.1 Test specimen joints shall meet the requirements of Paragraph 4.1.

U

5.0 PACKAGING, HANDLING AND STORAGE:

5.1 All production connector components and welded connector assemblies shall be stored in covered containers. The containers shall have individual compartments to protect the components and assemblies from indentations, scratches and mutilation. Special care and handling shall be exercised to prevent damage to the intricate components and assemblies.

6.0 NOTES:

6.1 WARNING NOTES:

6.1.1 All operational and maintenance personnel of laser welding equipment must be trained and knowledgeable in radiation and electrical hazards of laser safety. The invisible CO_2 laser radiation will seriously burn skin and eyes. Keep hands and arms away from the laser beam area when the shutter is open. Protective safety glasses with side shields shall be worn at all times when in the laser processing room. Do not look directly at the arc during the welding process. The laser processing room shall have a controlled entrance to inhibit entry while beam is being emitted from machine.

BENDIX CONNECTOR OPERATION

MATERIALS LABORATORY TEST REPORT

TO: File

REPORT NO: 9049

TYPE OF ANALYSIS

DATE IN: 12/5/88

DATE OUT: 12/7/88

____ METALLURGY

____ EFFLUENT

____ ORGANIC

____ GOLD

____ SERVICE REQUEST

____ CADMIUM

SAMPLE SU...

X METAL JOINING

SAMPLE SUBMITTED BY: B. Dunham

BACKGROUND: Bead on plate laser weld trials were to be performed to establish preliminary parameters for welding of 10-567150-26S type LJT-LAC/Filter hooded connectors.

OBJECT OF TEST: Measure weld penetration in 302 stainless steel coupons, approx. .025" depth required.

TEST RESULTS

1. Coupons were welded to the following parameters:
   Lens - 2.5"
   Cover gas - single cover, plant Argon, steel ball - 80
   Frequency - 1000 HZ.
   Pulse length - 0.2ms.
   Focus - @ surface
   Speed - 12.5"/min.

2. Penetration results are as follows:

Wattage	Depth (in.)	Max. Width (in.)
150	0.0168	0.0148
200	0.0220	0.0188
225	0.0328	0.0240
250	0.0352	0.0240
275	0.0360	0.0240

TESTED BY: B. Dunham

CC: A. Schildkraut
B. Ritchey

DF-3

BENDIX CONNECTOR OPERATION

MATERIALS LABORATORY TEST REPORT

TO: Hugh Kearney

REPORT NO.: 9170

DATE IN: 2/6/89

DATE OUT: 2/24/89

70651K X001

TYPE OF ANALYSIS

___	METALLURGY	___	EFFLUENT
___	ORGANIC	___	GOLD
___	SERVICE REQUEST	___	CADMIUM
x	METAL JOINING	___	___

SAMPLE SUBMITTED BY: Experimental

BACKGROUND:

10-567146-26S stainless steel hooded LAC connectors were submitted for laser welding. The parts were to be welded at a lower power setting compared to the previous batch as reported per TR 9127.

OBJECT OF TEST: Laser weld the six parts using 135 watts power and cross section one sample for fusion zone examination. A 2.5 [illegible] [illegible] was used.

TEST RESULTS

1. Five of the six parts were successfully welded. One part exhibited burn-through and lifting of the hood about half the distance around the circumference.
2. Cross sectioning reveals a weld fusion zone of .0175" deep by .0125" wide in area opposite from burn-through.
3. These parameters do not achieve the desired .012" deep penetration as hoped. It appears more experimentation needs to be performed if the desired penetration must be established and maintained.

TESTED BY: B. Dunham

B. Dunham

CC: A. Schildkraut

BENDIX CONNECTOR OPERATION

MATERIALS LABORATORY TEST REPORT

TO: H. Kearney   REPORT NO: 9459

TYPE OF ANALYSIS   DATE IN: 10/3/89

_____ METALLURGY   _____ EFFLUENT   DATE OUT: 10/17/89

_____ ORGANIC   _____ GOLD

_____ SERVICE REQUEST   _____ CADMIUM   C70651K X001

X METAL JOINING

SAMPLE SUBMITTED BY: Experimental

BACKGROUND: Thirty nine 10-567146-265 hooded LAC connectors were submitted for laser welding. Similar parts had been previously welded at BCO and several problems were encountered. A 3.75 inch focal length welding lens was to be used to minimize beam clipping during welding in the deep, narrow trough.

OBJECT OF TEST: Perform welding trials with the 3.75 inch lens and develop a reliable welding process for the hooded LAC connectors.

TEST RESULTS

1. Welding trials comparing the 3.75" and previously used 2.5" lens were performed and penetration results are as follows:

Watts	2.5" lens depth (in.)	3.75" lens depth (in.)
115	.0152	.0064
125	.0176	.0072
135	.0184	.0096
145	.0208	.0112
155	.0216	.0136
165	.0216	.0156

Note: All trials were welded according the attached weld schedule except for varying the power.

TESTED BY: B. Dunham

CC: A. Schildkraut
T. Marks
J. Badolato

TEST RESULTS (cont.)

2. Problems with the welding were encountered. They included: burn-through of hood flange, occasional crater holes in the fusion zone, burned side walls of the hood, and a burnt phenolic smell coming from the parts.

3. It was ascertained that the cause of the burned-through hood was the hood flange was not in intimate contact with the shell. Intimate contact between joined members is essential in lap welding with a laser. Two potential causes of improper hood seating were: a) eccentricity of the hood flange after molding causing the insert to hang up on the shell/recess corner and b) interfacial seals being added to the assemblies which were not previously used. A dimensional study of the LAC assembly needs to be performed and corrections made to provide for intimate/360° contact of the hood flange with the shell face.

4. The occasional crater holes noticed in the fusion zone were vastly reduced by incorporating a power ramp down at the end of the welding cycle.

5. The burned hood side walls was corrected by shimming the rotary welding fixture to provide part perpendicularity with the welding beam. (The rotary had been removed from the welding bracket to provide access for tapping holes for use on the LAC/Filter weld. When reinstalled on the bracket it was not trued up for perpendicularity.)

6. A longitudinal microsection was made of a live assembly and the depth of penetration was found to be .0128" deep by .0160" max. width (see Photo No. 1). The weld was later moved to the center of the trough between the shell and hood.

7. A note on the Engineering Drawing needs to be added to remove mold flash and clean the bottom of the hood flange after molding of the insert. This along with the rotary perpendicularity correction should prevent any phenolic burning.

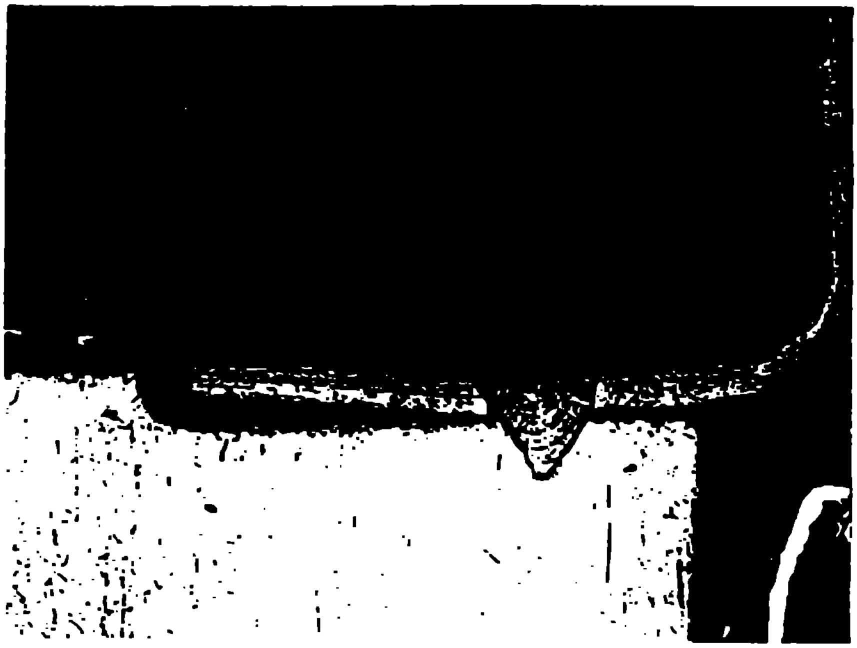


Photo No. 1

Mag: 50X

Etchant: 10% Oxalic, Electrolytic

Comments: Cross section of LAC assembly. Fusion zone is .0128" deep by .0160" max. wide.

Amphenol Corporation
Bendix Connector [illegible]

Laser WELDING SCHEDULE

Part No.: 10-567146-26S
Oper. No.: 751
Pg. 1 of 1
Change No.: B
Originator: B. Dunnam
Date: 10/12/89

Assembly Name: Connector, Electrical Receptacle, Hooded, Type [illegible] Size 17-26S

Applicable Documents: 9-4187 Note: All parts to be welded shall be clean. CAUTION: Do not handle weld joint area for it is very detrimental to laser welding.

Equipment Type: Coherent Everlase 325 CO_2 Laser

Trained Operator: Required

Tooling Requirements:

Tooling Set-up:

Weld Parameters:

Lens size ("): 3.75
Gas coverage: Argon-single
Pulse length (ms.): 0.2
Frequency (Hz.): 1000
Welding Speed (in./min.): 25

Mode: CW ___ SP ___ REP X
Total weld time (sec.): ______
Power (Watts): 140
Focus: @ surface
Rotary fixture speed (RPM): 9.3
Gate (ms.): 5500

Welding Instructions:

Pattern No.: 4
Weld origin absolute coordinates: XA: ______ YA: ______

Inspection: Applicable documents: 9-4187 Sec. 10 Inspection Type: I

Special Requirements: .008"/.012" total weld penetration is desired.

BENDIX CONNECTOR OPERATION

MATERIALS LABORATORY TEST REPORT

TO: J. Badolato — REPORT NO: 9560

TYPE OF ANALYSIS — DATE IN: 12/11/89

DATE OUT: 2/5/90

_____ METALLURGY _____ EFFLUENT

_____ ORGANIC _____ GOLD

_____ SERVICE REQUEST _____ CADMIUM

X METAL JOINING _____ _______

SAMPLE SUBMITTED BY: J. Badolato

BACKGROUND: A study was performed regarding focal point height adjustment during laser welding of 10-567146-26S hooded LAC connectors. Previous welding problems with regard to curling hood lips, burned through hood lips, and erratic fusion zones. A stack-up of height tolerance on the engineering drawing was found to be +/- .0065". Penetration depth of .0128" was noted when the parts were welded previously.

OBJECT OF TEST: Weld samples using different focal height adjustments looking for weld anomalies and depth of penetration.

TEST RESULTS

1. Samples were welded according to the previously established weld schedule except for height adjustments. Four different settings were used: .007" above, .007" below, .013" above, and .013" below.

2. All four samples exhibited hood lip curling. The two samples that were focused .013" above and below were welded using a shell in which the step had been completely removed by Experimental.

3. A sample was welded focused .007" above the surface and burn through of the hood with almost no penetration into the shell was noted.

4. The next sample was focused .007" below the surface and a depth of penetration of .009" was noted.

5. A third sample was focused .013" above and a depth of penetration of .0084" was found. Burn through of the hood was discovered in one small area.

TESTED BY: [signature]

CC: A. Schildkraut
R. Normann

DF-3

6. The final sample was focused .013" below and had a penetration depth of .0105".

Conclusions/Recommendations: Burn through of the hood flange was very pronounced on the sample focused .007" above the surface. The .013" above surface sample also exhibited burn through. It is recommended that the stack-up of height tolerance should be reduced to minimize the chance of burn through. In addition to this it appears that a below surface focal point is also advantageous.

Amphenol Corporation
Bendix Connector Operations

Part No.: 10-567146-26S
Oper. No.: 751
Pg. 1 of 1
Change No.: B
Originator: B. Dunham
Date: 10/12/89

LASER WELDING SCHEDULE

Assembly Name: Connector, Electrical Receptacle, Hooded, Type LJT-LAC, Size 17-26S

Applicable Documents: 9-4187 Note: All parts to be welded shall be clean. CAUTION: Do not handle weld joint area for it is very detrimental to laser welding.

Equipment Type: Coherent Everlase 325 CO_2 Laser

Trained Operator: Required

Tooling Requirements:

Tooling Set-up:

Weld Parameters:
- Lens size ("): 3.75
- Gas coverage: Argon-single
- Pulse length (ms.): 0.2
- Frequency (Hz.): 1000
- Welding Speed (in./min.): 25

Mode: CW ___ SP ___ REP X
Total weld time (sec.): ______
Power (Watts): 140
Focus: @ surface
Rotary fixture speed (RPM): 9.3
Gate (ms.): 5500

Welding Instructions:
- Pattern No.: 4
- Weld origin absolute coordinates: XA: ______ YA: ______

Inspection: Applicable documents: 9-4187 Sec. 10 Inspection Type: I

Special Requirements: .008"/.012" total weld penetration is desired.

BENDIX CONNECTOR OPERATION

MATERIALS LABORATORY TEST REPORT

TO: R. Selfridge | REPORT NO: 9791

TYPE OF ANALYSIS | DATE IN: 7/5/90

_____ METALLURGY   _____ EFFLUENT | DATE OUT: 7/9/90

_____ ORGANIC   _____ GOLD | CONTRACT:

_____ SERVICE REQUEST   _____ CADMIUM | EWOM:

X METAL JOINING

SAMPLE SUBMITTED BY: R. Selfridge

BACKGROUND: Laser welding of 42 pieces of hooded LAC connectors, 10-567146-26S, was accomplished with new spring loaded tooling. (Work Order F542969) The tooling design conceivably negated the excessive length tolerance (.013") stack up within the shell. Elimination of this tolerance maintains a focused laser beam at the weld surface. The anticipated result is improved weld penetration consistency. After welding, four assemblies had fusion zone anomalies. Two assemblies had single weld holes and would still meet the visual requirements of 9-8979-1. Two assemblies had unacceptable weld burn-through amounting to forty percent of the weld circumference.

OBJECT OF TEST: Perform metallograpic analysis on four assemblies with weld anomalies to determine cause of defects.

TEST RESULTS

SINGLE HOLES IN WELD: One assembly exhibited splattered glass on the shell's welding surface at the location of the hole. In Photo 1, the weld penetration remote from the hole was found to be .0136" with no joint separation. This is typical for the established weld schedule. Inadvertently, the second sample's weld hole was lost during metallographic preparation and the weld contamination could not be viewed.

BURN-THROUGH: Inspection of the welds in an area remote to the burn-through revealed excessive joint separation in both assemblies. Joint separation was .0022" and .0034" in the areas where fusion into the shell was still apparent. Weld penetration dropped to .0106" and .011" in these areas, however it still meets the minimum requirement of .010". (See Photo 2) Burn-through is characteristic of excessive joint separation. Basic design rule for laser welding shall maintain

C. A. Schildkraut, R. Knight
P.Players, M. St. John

Reported By Barb Ritchey
B. Ritchey

<u>BURN-THROUGH</u>:
a joint separation to within 1/2t, when t is equal to stock thickness of the thinnest member. In this case, the flange is .005" and the maximum separation should be .0025". Excessive separation can be attributed to a number of things: improper assembly of molded hooded insert into the shell; uneven clamping force on top of hood; or excessive clamping force. Although joint separation can be tolerated and still achieve the required weld penetration, maximum obtainable strength is with no separation.

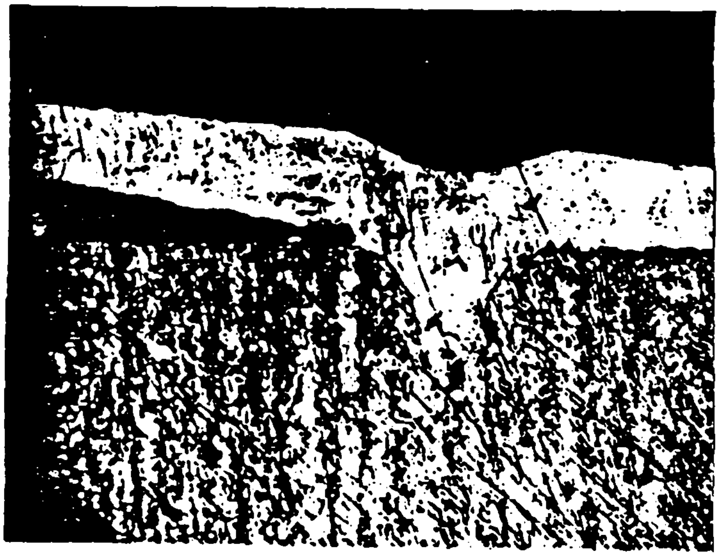


Photo 1: Mag 100X

Etchant: NH_4OH & H_2O_2

Comments: Photo reveals weld penetration and no joint separation to the right of the weld. End of flange is the left of weld nugget. Weld is in area remote to a singular weld hole.

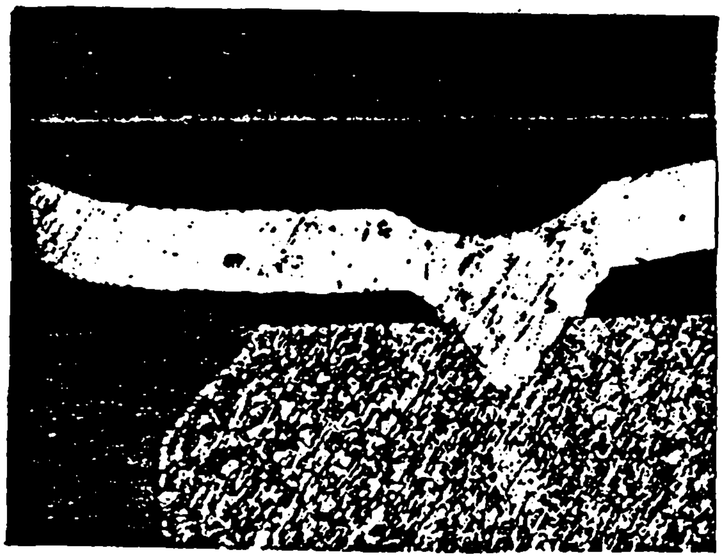


Photo 2: Mag. 100X

Etchant: NH_4OH & H_2O_2

Comments: Photo exhibits the affect of excessive joint separation and decrease of weld penetration into the shell. At a 180 degrees from this location, excessive separation results in burn-through.

Amphenol Corporation
Bendix Connector Operations

Part No.: 10-567146-2
Oper. No.: 751
Pg. 1 of 1
Change No.: C
Originator: B. Ritch
Date: 8-26-91

LASER WELDING SCHEDULE

Assembly Name: Hooded Receptacle Connector, Type LJT-LAC, Size 17-26S

Applicable Documents: 9-4187 and 9-8987-1
Note: All parts to be welded shall be clean. CAUTION: Do not handle weld joint area for it is detrimental to laser welding.

Equipment Type: Coherent Everlase 325 CO2 Laser

Trained Operator: Certified ~~CO~~ 9-8987-1 and 9-4187

Tooling Requirements:
Nest: 44-179569
Rotational Motor and Support Bracket: 44-159142 (Weld Flat)
Clamp to be centered on hood applying light pressure
Spacer: 44-180028 Adjust nest .174 inch from bottom of motor shaft

Tooling Set-up:
.174 inch from base of rotary shaft to bottom of nest
9.75 inch from top of aluminum bracket to thread seam of lens
Pusher clamp should rotate during rotation

Weld Parameters:
Lens size ("): 3.75
Gas coverage: Argon
Pulse length (ms.): .2
Frequency (Hz.): 1000
Welding Speed (in./min.): 25

Mode: CW ___ SP ___ REP X
Total weld time (sec.): 6.3
Power (Watts): 175 on: 155 gate
Focus: .005" below surface
Rotary fixture speed (RPM): 9.3
Gate (ms.): 5500

Welding Instructions:
Pattern No.: 4
Weld origin absolute coordinates: XA: ______ YA: ______
Patten No: 6 Bead On Plate

Inspection: Applicable documents: 9-4187 Sec. 10 Inspection Type: I
9-8987-1 weld penetration

Special Requirements: Total weld penetration of .010- 016 inch is required. Operator and weld schedule certification on Materials Laboratory Test Report No. 10149.

BENDIX CONNECTOR OPERATION

MATERIALS LABORATORY TEST REPORT

TO: Tony Fournier

REPORT NO: 10149

TYPE OF ANALYSIS

DATE IN:

DATE OUT: 9/5/91

CONTRACT:

EWOM:

______ METALLURGY	______ EFFLUENT
______ ORGANIC	______ GOLD
______ SERVICE REQUEST	______ CADMIUM
X METAL JOINING	______ ______

SAMPLE SUBMITTED BY: Ritchey

BACKGROUND: Weld parameter repeatability and operator certification must be verified on 10-567146-26S hooded LAC. Weld penetration shall be .010 - .016 inch per 10-567146-26S weld schedule.

OBJECT OF TEST: Establish weld parameter and operator certification per 9-8937-1.

TEST RESULTS

All samples utilized for weld schedules certifications were also used for Roger Robinson's operator certification.

The bead on plate verification exhibited .0142 inch total penetration on 304L material. See Photo No. 1.

Two actual hermetic LAC assemblies were welded and microsectioned for weld penetration determination. Penetration was measured in two locations, approximately 180° apart. Penetration varied from .0096-.0153 inch. The lowest penetration was obtained at the narrow gap between the hood OD and the shell ID. Beam clipping is occurring in this portion of the circumference were the gap is only .076 inch. It appears that the hermetic contact pattern is eccentric to the shell inside diameter. Photomicrographs 2-5 illustrate the weld fusion zones of the two samples.

Although the weld parameters and operator are certifiable, the dimensional anomalies within the hermetic connector are contributing to the weld penetration instability. There is no assurance that the minimum weld penetration will be obtained with this eccentricity and beam clipping.

Reported By Bob Ritchey
Metallurgist

CC. J. Fisher, W. Haney, A. Schilkraut

RECOMMENDATIONS: Total inside diameter variation shall be decreased on the 1.016 and .931 ID. The 1.016 ID should be maintained as low as possible and the .931 ID should be maximized. Eccentricity between these diameters should be decreased where possible. Hermetic sealing fixtures should be changed to locate on weld end of assembly and held concentric to the shell inside diameter.

A five inch focal length lens will decrease the beam clipping. However, maximum achievable working distance has been obtained with the existing tooling and the 3.75 inch lens. Receipt of the new optical viewing system for the laser will increase the working distance allowing the use of a 5 inch lens. This will require redevelopment of the weld parameters and recertification.

METALLOGRAPHIC ANALYSIS OF WELDS:

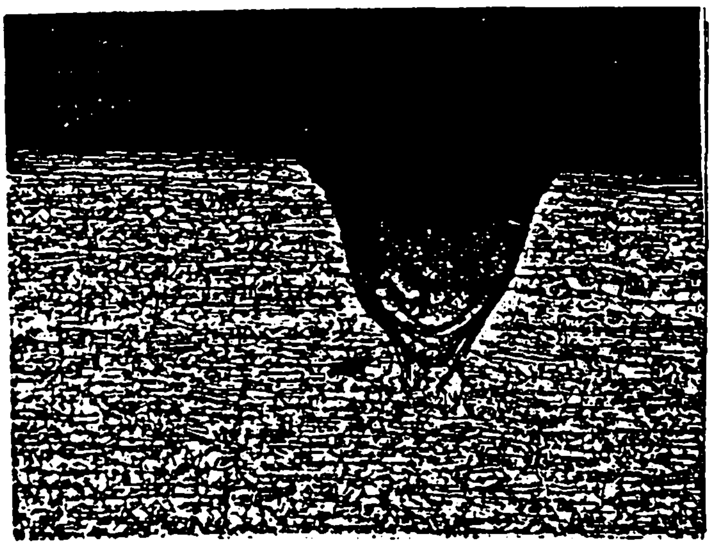


Photo No. 1

Mag: 200x

Etchant: Electrolytic Oxalic Acid

Comments: Bead on plate weld sample exhibited .014 inch weld penetration.

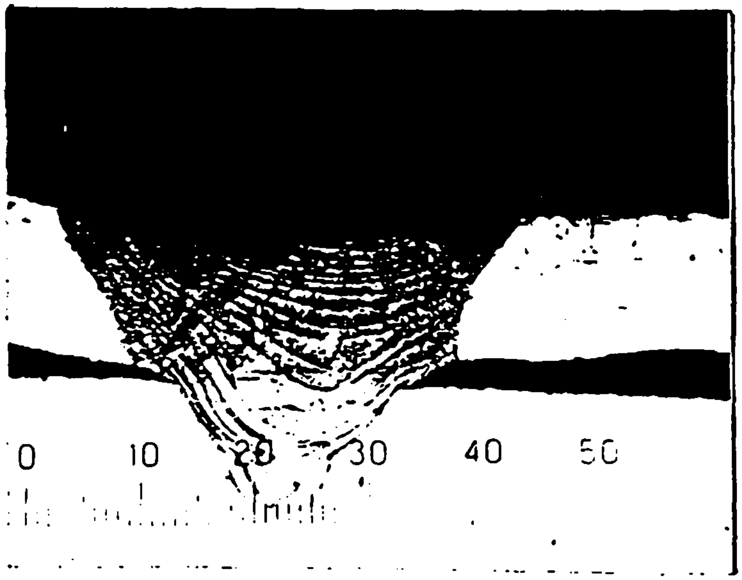


Photo No. 2 Sample 1

Mag: 150X

Etchant: Electrolytic
Oxalic Acid

Comments: Fusion zone of welded LAC reveals .010 inch weld penetration. Joint separation at left of fusion zone is the result to metallographic sample preparation. Separation at right of fusion zone is joint separation from improper seating of hood flange.

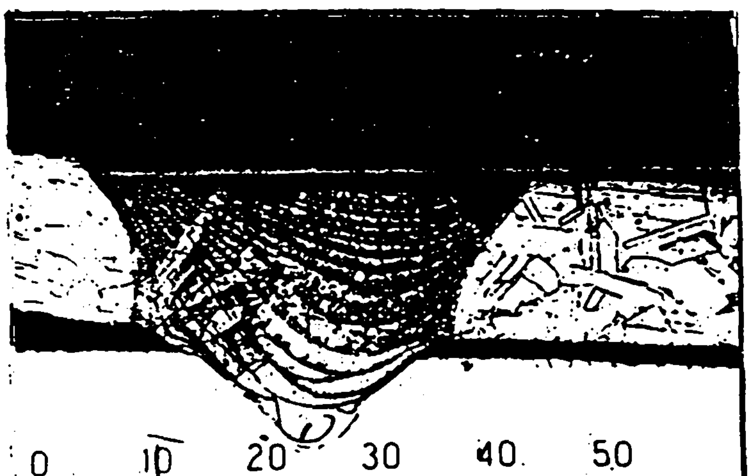


Photo No. 3 Sample 1

Mag 150X

Etchant: Electrolytic
Oxalic Acid

Remarks: Fusion zone 180° from that represented in Photo No. 2 has .0096 inch weld depth. Joint separation at left of weld is from sample preparation. The right side demonstrates actual separation of .0006 inch. It appears that the insert assembly wasn't seated properly.

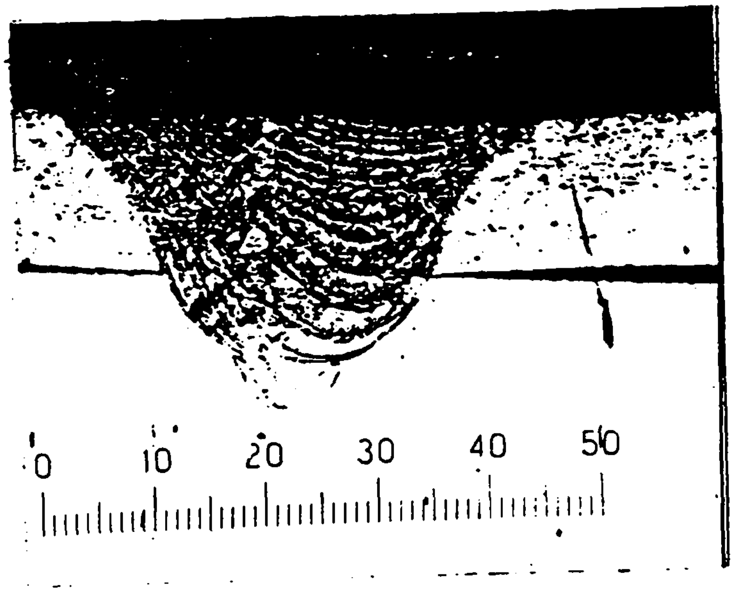


Photo No. 4 Sample 2

Mag 150X

Etchant: Electrolytic
Oxalic Acid

Remarks: Total weld penetration is 0.0116 inches. Joint separation at right of fusion zone is the result of sample preparation. Negligible separation is apparent at the other side of the weld. The drop in fusion depth is the result of beam clipping.

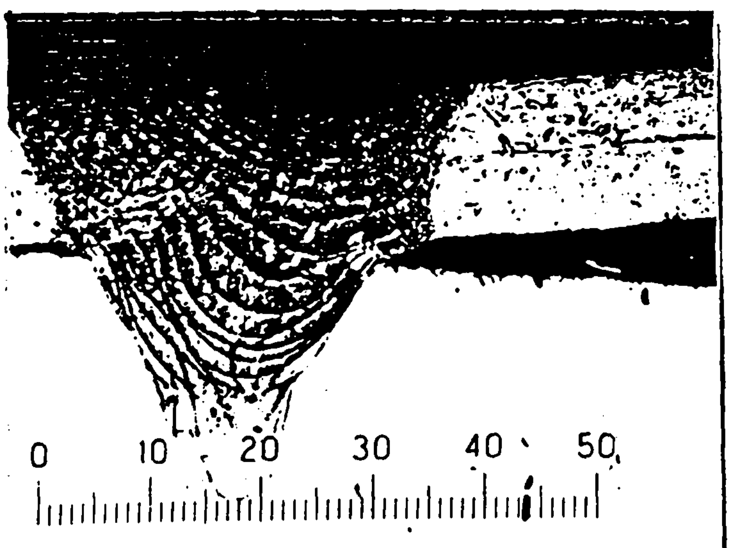


Photo No. 5 Sample 2

Mag. 150X

Etchant: Electrolytic
Oxalic Acid

Remarks: Weld at 180° from microsection in Photo No. 4 has 0.015 inches This depth of weld is representative of the bead on plate penetration.

SA 3581 Hooded LAC Laser Welding
with optical viewing system

1) Welding with a 3.75" focusing lens clips the sides of the hood and shell ID during welding. We have had problems with welding burnthrough of the hood's flange. Burnthrough can be the result of several things such as an excessive gap between components or a defocused beam. A five inch lens should clear the component but the work distance of BCO's laser is inadequate with our hard-tooling set-up to accomodate the necessary focal length. A new optical viewing system will re-route of laser beam, picking up the necessary working distance for a 5" lens and our hard-tooling. With an optical viewing system the set-up will be simplified. It will be easier to find the center of cavity between the hood and shell. Keep in mind, this is not a laser tracking system. Such systems are extremely expensive and I never intended to have anyone believe that's what we're getting

This optical viewing system is unique for CO_2 lasers. Viewing systems have been on YAG lasers for a long time, but the difference in laser wave lengths make a coaxial light and optical system very Special for CO_2 lasers

APPENDIX B

SA3581/MC4196 Product Configuration System

CONTENTS

SINGLE ENTRY LISTING
SA3581 - 411447 -01

DRAWING NO.	ISSUE	REL STATUS	DRAWING TITLE
AF260624 -000	C	RELE	OPER PROC
AF260625 -000	C	RELE	OPER PROC
AF260626 -000	C	RELE	OPER PROC
AF394023 -000	B	CER	OPERATING PROCEDURE
AMS5514		RELE	STAINLESS STEEL DRAW
AMS5647		RELE	CRE STEEL
ASTM-B-196			BERYLLIUM COPPER, DO
ASTM-B-197			ALT ITEM 10
DF197072 -REF			REF ONLY
DF411447 -REF			REF ONLY
DF411447 -000	A	AER/DTER	DATA TRANSMITTAL FOR
DR411447 -000	B	AER/DTER	DATA REQUIREMENTS, S
MIL-G-45204		RELE	PLATING, ELECTRODEPO
MIL-I-23011		RELE	GLASS SEALING
MM411447-T1 -001	C	NONE	GAGE BACK END
MS27502A17A			ELECTRICAL CONNECTOR
PS411447 -REF			REF ONLY
PS411447 -000	G	CER	PRODUCT SPECIFICATIO
SS380821 -REF			* NOT ON FILE *
SS392469 -000	B	CER	WELDING, LASER, SA35
UA6116 -000	C	CER/DTER	CONTACT RESISTANCE T
356323 G001	A	CER	GAGE NO GO
356328 G002	A	CER	GAGE GO NO
357823 G001	H		GAGE DUM SHT
357942 G002	C		GAGE DUM SHT
357942 G003	C		GAGE DUM SHT
411447 -01	G	CER	SA3581
9900000 -	AB	RELE	GENL MFG REQ*

SINGLE ENTRY LISTING
SA8581 - 411447 -01

DRAWING NO.	ISSUE	REL STATUS	DRAWING TITLE
9919100 -	BE	RELE	MARKING, GENERAL MET

29 rows selected.

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DPC308RS DEPARTMENT PRODUCT CONFIGURATION SYSTEM 10/21/91 PAGE 1

SINGLE ENTRY LISTING

4196 - 412084 -01

DRAWING NO.	ISSUE	REL STATUS	DRAWING TITLE
AF-GA8258 -000	B	CER	OPERATING PROCEDURE
AF-PT3186 -006	T	RELE	OPERATING PROCEDURE,
AF-PT3290 -007	U	CER	OPERATING PROCEDURE,
AF394028 -000	B	CER	OPERATING PROCEDURE
AMS3651		RELE	POLYTETRAFLU
AMS46819 -002	D	CER	TESTER OF PT3290
AMS92980			RCD CREATED DUE TO I
AMS94420			RCD CREATED DUE TO I
ASTM-B-1353			NONVOLAT MAT
ASTM-B-196			BERYLLIUM COPPER, DD
ASTM-B-197			ALT ITEM 10
ASTM-D-1002			TENSILE STR
ASTM-D-1125			WATER CONDUCT
ASTM-D-1193			REAGENT WATER
ASTM-D-1209			COLOR
ASTM-D-1214			GLASS TEST
ASTM-D-1353			NONVOL MAT
ASTM-D-1368			RCD CREATED DUE TO I
ASTM-D-1613			ACIDITY IN VOLATILE
ASTM-D-1639			ACID VALVE
ASTM-D-1652			EPOXY CONTENT
ASTM-D-1726			CHLORINE CONT
ASTM-D-1963			SPEC GRAVITY
ASTM-D-2109			NON-VOLATILE MATTER
ASTM-D-2393			VISCOSITY
ASTM-D-2840			MICROSPHERES
ASTM-D-2841			MICROSPHERES
ASTM-D-34			RCD CREATED DUE TO I

SINGLE ENTRY LISTING
4196 - 412084 -01

DRAWING NO.	ISSUE	REL STATUS	DRAWING TITLE
ASTM-D-501			RCD CREATED DUE TO I
ASTM-D-664			NEUTRAL NO
ASTM-D-859			RCD CREATED DUE TO I
ASTM-E-203			WATER TEST
ASTM-E-70			SPECIFIC GRAV
ASTM-F-50			RCD CREATED DUE TO I
DF412084 -000			
DR412084 -000			
FED-STD-209		RELE	CLEAN STATION
GA8255 -000		CER	GAGE BACK END
MIL-G-45204		RELE	PLATING, ELECTRODEPO
MIL-T-81533			VAPOR DEGREAS
MM411447-T1 -001	C	NONE	GAGE BACK END
MS27502A17A			ELECTRICAL CONNECTOR
MS90376 -15Y		RELE	PROTECTIVE CA
PS412084 -000	G	CER/DTER	PRODUCT SPECIFICATIO
PT3186 -REF		RELE	LAC VIBRATION TESTER
PT3186 -05	L	RELE	LAC VIBRATION TESTER
PT3290 -REF		CER	LAC TESTER
PT3290 -10	U	CER	LAC TESTER
QQ-S-763		RELE	SHEET OR ROD, SST, T
QQ-S-766		RELE	CRES
SB391076 -000	B	CER	VARISTOR GRANULE PRE
SE1252 -REF			LAC TESTER
SS258063 -200	D	CER	RELEASE AGENT
SS258072 -200	H	CER	ISOPROPYL ALC
SS258084 -200	D	CER	MOLD RELEASE
SS276940 -200	D	CER	ISOP ALCOHOL

SINGLE ENTRY LISTING

4196 - 412084 -01

DRAWING NO.	ISSUE	REL STATUS	DRAWING TITLE
SS294354 -200	AJ	CER	MAT'L & ENVIR FOR ST
SS295404 -200	C	CER	POLYMER
SS295729 -201	Y	CER	FILLER, HOLLOW GLASS
SS302227 -200	D	CER	ALT ITEM 6
SS303958 -200	A	CER	ABRASIVE GRIT
SS306045 -200	A	CER	POLYIMIDE
SS325318 -200	K	CER	RESIN, CTBN MODIFIED
SS331542 -200	E	CER	ADH PRESS SEN
SS346921			
SS390897 -200	A	CER/DTER	LASER BEAM WE
SS390912 -200	B	CER/DTER	ENCAPSULATION PREMIX
SS390913 -200	B	CER/DTER	ENCAPSULATION PROCES
SS390940 -200	A	CER/DTER	CLEANING AGEN
SS390941 -200	A	CER/DTER	ALUMINUM CLEA
SS391350			CHEM PREP OF LAC VAR
SS391350 -000	B	CER	CHEM PREP OF LAC VAR
SS392548 -200	D	CER	VARISTOR GRANULES AC
SS392750			
SS392751			
SS392752			
SS392753			
SS392754			
SS392755			
SS392756			
SS392757			
SS392758			
SS393277			
SS393278			

SINGLE ENTRY LISTING
4196 - 412084 -01

DRAWING NO.	ISSUE	REL STATUS	DRAWING TITLE
SS898279			
UA2217 -000	B	CER	ADAPT/PT8290
UA2236 -000		CER	55 PIN SIMUL
UA5902 -000	A	CER/DTER	ADAPTER 26-55 PIN
UA5927 -000	B	CER/DTER	REDUCER RING NUMBER
UA5939 -000	C	CER/DTER	HV ADAPTER, 26 PIN
UA6116 -000	C	CER/DTER	CONTACT RESISTANCE T
10023749 6005	B	RELE	LAC SHIPPING BOX
124A1105 P001	15	CER	ALCOHOL
124A1219	10	CER	ACETONE
124A1219 P001	10	CER	ACETONE
126A1494 P001	10	CER	EPOXY RESIN
178126	R	NONE	GENL SPEC
2140265 -	A6	RELE	ALT ITEM 1
295842 -204	R	CER	PACKAGING LAC
302080 -002	C	RELE	IR DUMMY LOAD
344700 -201	D	CER	INNER DISC CLEA
346940 -200	C	CER	OUTER DISC
386377 -200	J	CER	WEB
386402 -000	D	CER/DTER	ENVIRONMENTAL_H
388494 -200	C	CER/DTER	WEB-DISC ASSEMB
388953 -200	F	CER/DTER	UNIT ASSEMBLY
392586 -200	A	CER/DTER	INNER DISC
411447 -01	G	CER	6A5561
412084 -01	H	CER/DTER	MC4196 LAC
4160030 -	F	RELE	ALT ITEM 5
46A100670 P001	10	CER	DEION WATER
46A100670 P002	10	CER	DEION WATER

SINGLE ENTRY LISTING
4196 - 412084 -01

DRAWING NO.	ISSUE	REL STATUS	DRAWING TITLE
46A101252	15	CER	TOLUENE
46A101565			
46A101565 P001	9	CER	NITRIC ACID, REAGENT
46A101568 P001	14	CER	ARGON GAS
46A101576	10	CER	HYDROCHLORIC_ACID
46A101584 P001	12	CER	TRICHLOROETHY
46A101756 P001	7	CER	ANIONIC
46A101971 G001	7	CER	CLEAN PROC
46A102050 P001	9	CER	MOLD RELEASE
46A102073 P001	6	CER	DETERG NONION
46A102131 P001	8	CER	DETERG NONION
46A102151 P001	16	CER	TRICHLOROTRIF
46A102300	10	CER	THERMAL SHOCK EPOXY
46A102300 P001	10	CER	THERMAL SHOCK EPOXY
46A102303 P001	5	CER	NITROGEN
4604020 -	V	CER	CURING AGENT
9900000 -	AB	RELE	GENL MFG REQs
9919100 -	BE	RELE	MARKING, GENERAL MET

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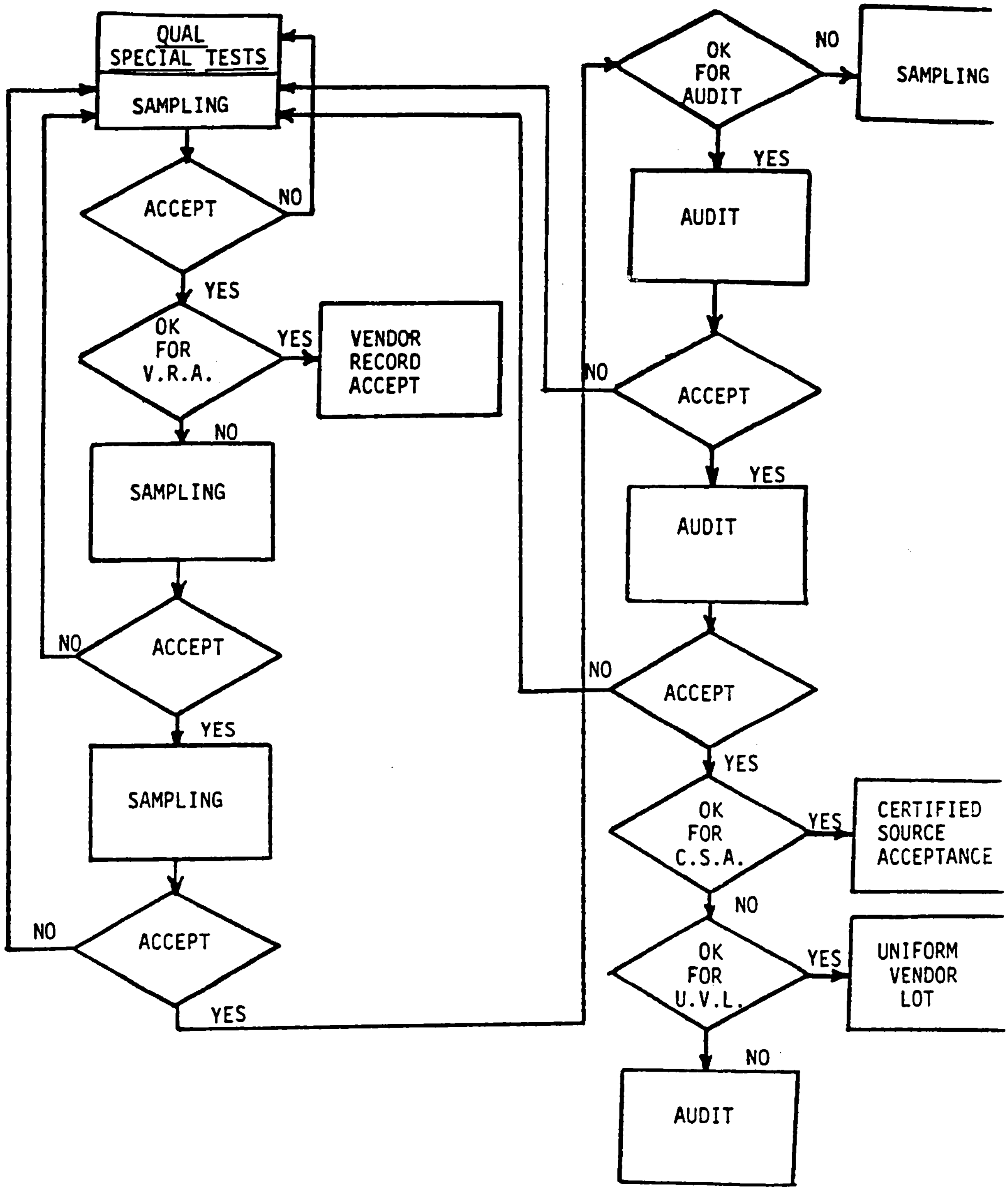
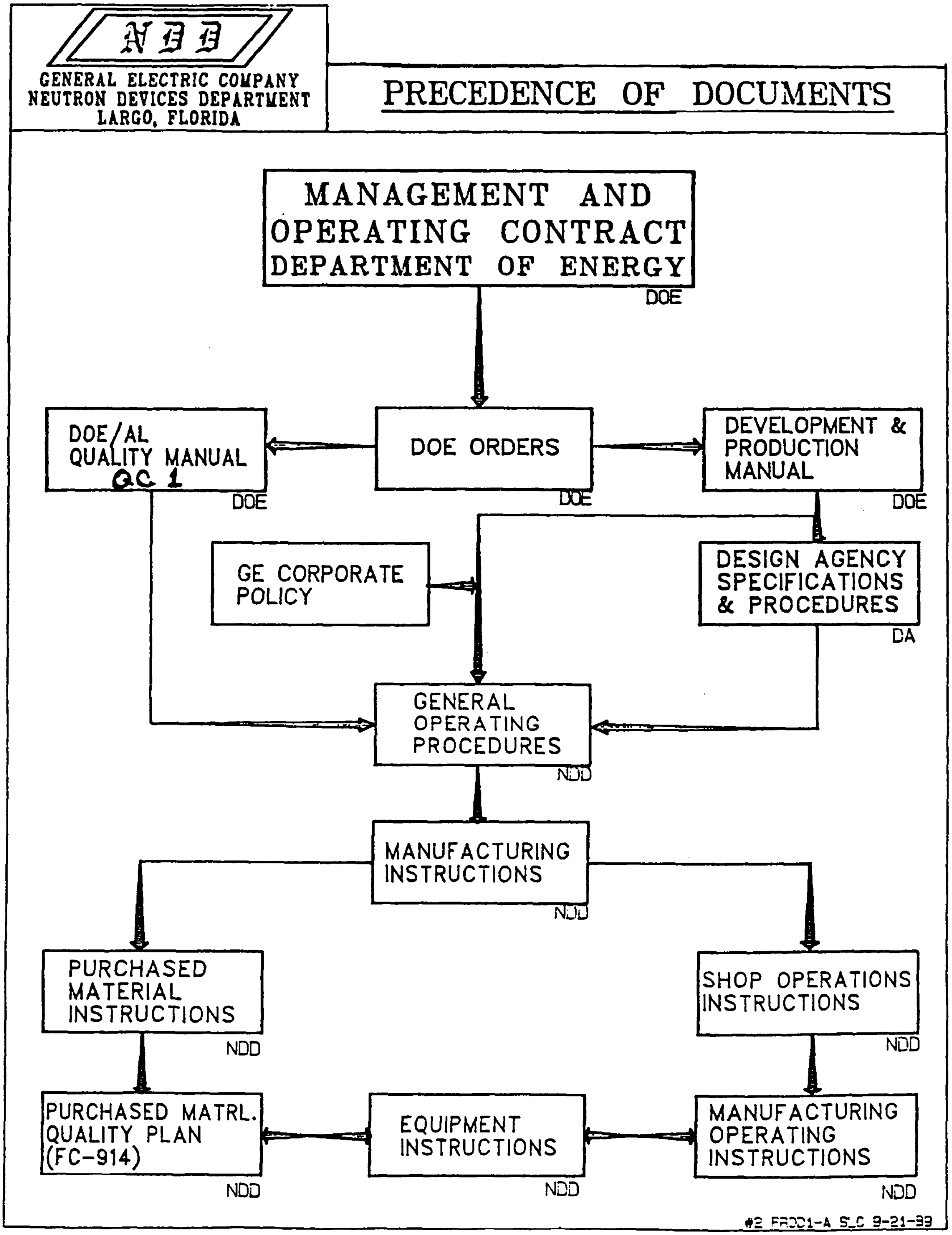
APPENDIX C

SA3581 Incoming Inspection

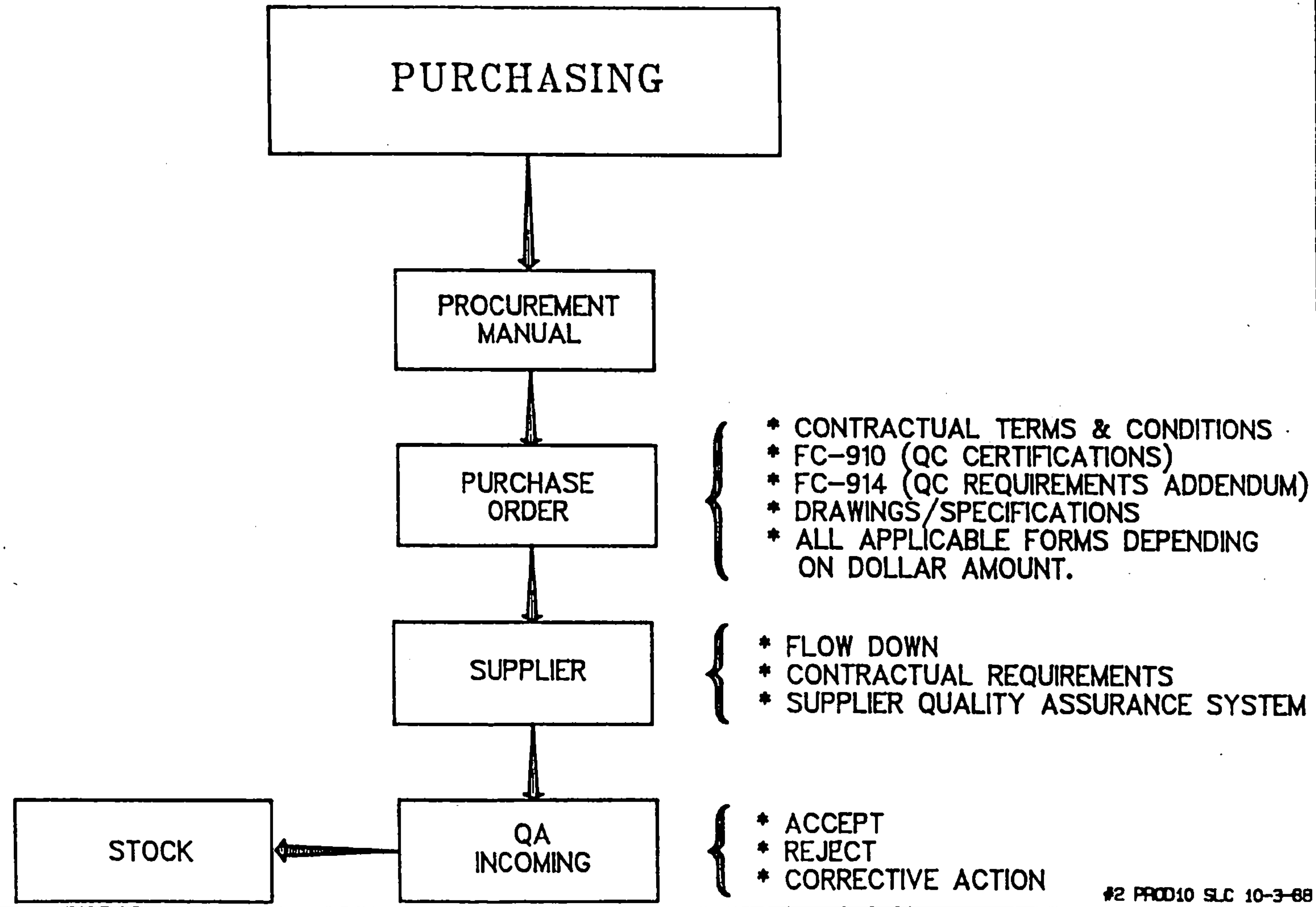


Incoming Test & Insp.
Procedural Flow


NDD
GENERAL ELECTRIC COMPANY
NEUTRON DEVICES DEPARTMENT
LARGO, FLORIDA
PRECEDENCE OF DOCUMENTS
MANAGEMENT AND OPERATING CONTRACT DEPARTMENT OF ENERGY
DOE
DOE/AL QUALITY MANUAL QC 1
DOE
DOE ORDERS
DOE
DEVELOPMENT & PRODUCTION MANUAL
DOE
GE CORPORATE POLICY
DESIGN AGENCY SPECIFICATIONS & PROCEDURES
DA
GENERAL OPERATING PROCEDURES
NDD
MANUFACTURING INSTRUCTIONS
NDD
PURCHASED MATERIAL INSTRUCTIONS
NDD
SHOP OPERATIONS INSTRUCTIONS
NDD
PURCHASED MATRL. QUALITY PLAN (FC-914)
NDD
EQUIPMENT INSTRUCTIONS
NDD
MANUFACTURING OPERATING INSTRUCTIONS
NDD

GENERAL ELECTRIC COMPANY
NEUTRON DEVICES DEPARTMENT
LARGO, FLORIDA

PRODUCT PROCUREMENT FLOW PROCEDURE



#2 PROD10 SLC 10-3-88

FC-914

NOTICE! THE MATERIALS OR PRODUCTS SUPPLIED MUST MEET THE REQUIREMENTS OF THIS DOCUMENT OR IT WILL BE RETURNED.

Purchased Material Quality

FC-914

GE Aerospace

Neutron Devices
General Electric Company
P.O. Box 2908
Largo. FL 34649-2908

PURCHASED MATERIAL QUALITY PLAN

THE ATTACHED INFORMATION IS AN INTEGRAL PART OF THE ORDER.

THIS INFORMATION IS PROVIDED AS AN AID TO THE SUPPLIER IN ASSURING PRODUCT CONFORMANCE TO GE REQUIREMENTS.

CERT'S REQUIRED WITH THIS ORDER

ATTN: QUALITY CONTROL

FC-910 (5/88)

GE Aerospace

Neutron Devices
General Electric Company
P.O. Box 2908
Largo, FL 34649-2908

QUALITY CONTROL REQUIREMENTS

Addendum to FC-914 (4/90)

1. Purpose
   1.1 Inform each supplier of the Quality Control criteria used by General Electric Neutron Devices Department (GEND) for acceptance of each lot or shipment of purchased production material.

2. Policy
   2.1 GEND will inform each supplier of acceptance criteria for each lot or shipment of purchased production material.
      2.1.1 The supplier can, unless otherwise restricted, use the most practical manufacturing process, inspection/test technique and quality plan to provide a product which will be acceptable to GEND.
   2.2 GEND will evaluate each lot of purchased production material in accordance with the Purchased Material Quality Plan (FC-914).

3. PRECEDENCE OF DOCUMENTS
   Should requirements of the following documents conflict, precedence shall apply in the order shown:
   3.1 Purchased Order/Shipping Notice
   3.2 Detail Drawing
   3.3 Associated Specification (in order of reference)

4. GENERAL
   4.1 Quality Control Field Engineers and the United States Department of Energy and /or its designated representatives shall have access to the supplier's plant to observe all pertinent operations and processes, unless exception (proprietary process) is presented to GEND Purchasing and Quality Control.
   4.2 Unless otherwise specified, MIL-STD-105D Sampling Tables and Procedures will be used by GEND.
   4.3 The GEND inspector/tester will use the equipment or gage listed on the Purchased Material Quality Plan to evaluate a true random sample (N/C column) of the supplier's lot for the quality characteristics specified.
   4.4 Certain specification characteristics are to be evaluated by GEND on each lot of product (lot acceptance).
   4.5 Additional specification characteristics not evaluated on a routine lot acceptance basis, FC-914 sequences with a Q suffix, are to be evaluated by GEND on the initial lot and periodically on subsequent lots (Qualification).
   4.6 Defects are classed on the FC-914 (CL column) as to relative importance to function or subsequent processing of the product. "A" shall designate a critical defect, " B" a major defect, "C" a minor defect and "D" an incidental defect.

5. GEND RESPONSIBILITY
   5.1 Before final rejection of supplier's product, all observed defects are verified by the responsible Quality Control Field Engineer.
   5.2 GEND Purchasing will report verified defective product to the responsible supplier and request supplier's corrective action.

6. SUPPLIER RESPONSIBILITY
   6.1 All product manufactured by the supplier or procured by the supplier from any other source shall be subject to sufficient inspection/test by the supplier to assure conformance to applicable GEND requirements.
   6.2 Manufacturing/inspection records, pertinent to GEND Purchase Orders, shall be available to GEND QC Field Engineers for review.
   6.3 Tools, gages and test equipment essential to perform inspection/test operations shall be provided by the supplier, unless the Purchase Order or FC-914 specifically states that they shall be furnished by GEND.
   6.4 To assure shipment of only acceptable product, the supplier shall use stamps, tags or other methods to identify all parts and assemblies that have been accepted or rejected by inspection/test. Defective/rejected material shall be segregated at all times.
   6.5 Samples subjected to destructive tests shall not be included in the shipped lot unless requested.

6.6 Maintain a record of changes concurrent with the effectivity of revised GEND requirements.

6.7 Drawing change control shall provide for removal of obsolete drawings and supporting information from all points of use.

6.8 Unless supplier sampling plans are specified by the specification, the supplier shall establish sampling plans to an equal or tighter level AQL/LTPD than those used by GEND.

6.9 The supplier, whenever practical, should establish guard bands on tolerances to prevent shipment of borderline product.

6.10 Lots failing to meet acceptance criteria for any sampling plan (except destructive tests) shall be inspected/tested 100 percent for the failing characteristic(s).

- 6.10.1 All observed defects shall be removed.
- 6.10.2 The lot shall be resampled for the failing characteristic(s) using the same sampling plan.
- 6.10.3 Lots failing the second sampling shall not be supplied without written approval by GEND.

6.11 The supplier shall maintain a calibration system that will provide the means to directly or indirectly trace assigned values of measurement equipment to values in terms of nationally recognized standards and assure that gages and test equipment, including commercial test equipment, are in a state of proper calibration and maintenance.

6.12 Lots containing known defectives shall not be shipped to GEND.

6.13 The supplier shall notify GEND of any significant changes in material, tooling, processes or manufacturing facility for the product.

7. <u>CERTIFICATION</u>

Required vendor product certification (if applicable) is defined on the Purchased Material Quality Plan (FC-914) and specified on the Purchase Order.

7.1 Certification is to be verified and signed by an individual responsible for verification of product conformance to all specifications and Purchase Order requirements.

7.2 Certification are to accompany each and every shipment.

7.3 Product supplied without certifications or with incomplete certifications will not be accepted pending review.

7.4 Test data requirements that will result in additional costs to GEND should be noted in all quotes to Purchasing.

8. <u>QUALITY CONTROL FIELD ENGINEER</u>

Has assigned responsibility for:

8.1 Periodically surveying all operations, processes and systems of suppliers as they relate to GEND orders.

8.2 Interpreting drawings, specifications and QC requirements; answering or obtaining answers to questions concerning GEND requirements; and conducting correlation studies with intent of establishing compatible inspection/test techniques.

8.3 Assuring that all suggestions or recommendations given to the supplier are compatible with the contractural requirements.

GENERAL ELECTRIC COMPANY NEUTRON DEVICES DEPARTMENT PURCHASED MATERIAL QUALITY PLAN FC-914	Issue Date 08/15/91	Drawing 411447	Suffix -01		Rev. C ~~B~~	Description CONNECTOR (SA3581)	Page 1 of 11
	Effective 9214 SFR ~~[illegible]~~	QC Field Eng. LK BRADLEY	QC Engineer LK BRADLEY	MC Number 4196		Reviewed By K Bradley	Library Ref. 0422C-0286K

GE Lot No.	Qual (X)	P.O. Number	Qty Rec'd	Unit	Vendor		Vendor Lot No.

Date Rec'd.	Date Start	Date Comp.	Qty to Stock	Qty Rejected	QCR No.	MRB No.	Inspector

Disposition	Vendor Rating	Completed Package Reviewed By Foreman: QVMC: QCFE:

REQUIRED VENDOR PRODUCT CERTIFICATION

Statement of Compliance to GEND Drawing No. 411447-01 Rev. G

INCLUDING: Quantity Shipped *Lot Size

*NOTE: The Lot Size Shall Not Exceed 200 Units.

ASSOCIATED SPECIFICATIONS AND GAGES

Gages Supplied By GEND

411447-11

VENDOR SPECIAL INSTRUCTIONS

Marking & Packaging

Each connector shall be accompanied by ~~a paper tag~~ Identification bearing the designator SA-3581, applicable Part Number, Suffix and Serial Number. Connectors having been subjected to Lot Sample Tests for Test Prod Damage and Coupling shall be so identified. Connectors shall be packaged to prevent damage and contamination.

Storage

None

K. BRADLEY

GEND SPECIAL INSTRUCTIONS

Marking & Packaging

Each connector shall be accompanied with ~~a paper tag~~ identification Tag bearing the designator SA3581, applicable Part Number, Suffix and Serial Number until Laser Marking has been accomplished.

Storage

None

Shelf Life

None

Handling

None

Safety

Always

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments

PREPRODUCTION

LOT SAMPLE TEST CONDITIONING: ITI

Before Any Further Processing, Segregate and Submit The Six (6) or More Connectors Identified as Lot Samples to Unit 492 (Bldg. 200) For Environmental Conditioning.

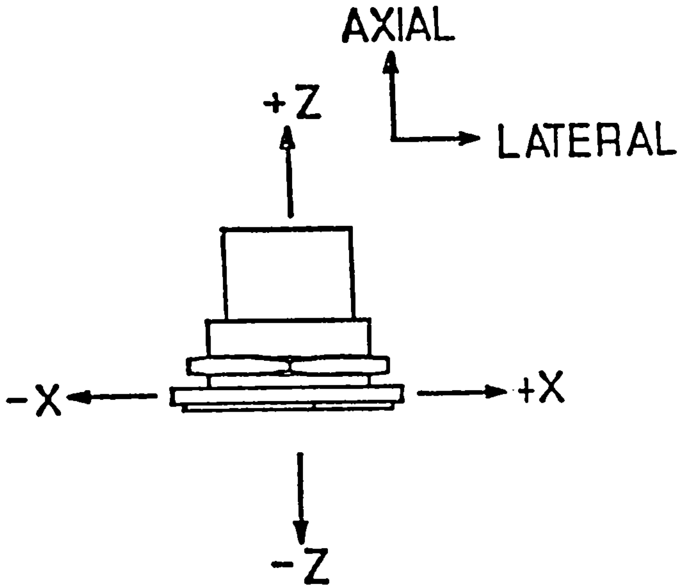
BUILDING 200 - UNIT 492 ITI - Service Request Must Contain Manufacturer's Code, Lot Number, Drawing Number and Serial Numbers of Connectors. Contact QCE for Information.

Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	AQL/LTPD	N/C
010	CHAR: Mechanical Shock SPEC: Stabilize Connectors at 22 ± 6°C and Ambient Pressure. Subject Connectors to two shocks in each of the +X, +Z, and -Z Axes. The Shocks shall approximate the Haversine Pulse having an Amplitude of 375g ± 15% and a duration of 6.0ms ± 15%. See Page 3 for Axies definition. EQPT: 272 X 289 HVA	PS411447 9958003	3.2.3	- - -	100%
020	CHAR: Random Vibration SPEC: Stabilize Connectors at 22 ± 6°C and Ambient Pressure. Subject Connectors to the random virbation spectrum shown on page 3 for 30 ± 3 minutes in the X-Axis and 30 ± 3 minutes in the Z-Zxis. EQPT: Vibration System as required	PS411447 9958004	3.2.4	- - -	100%

PURCHASEL ATERIAL QUALITY PLAN - Continued FC-914

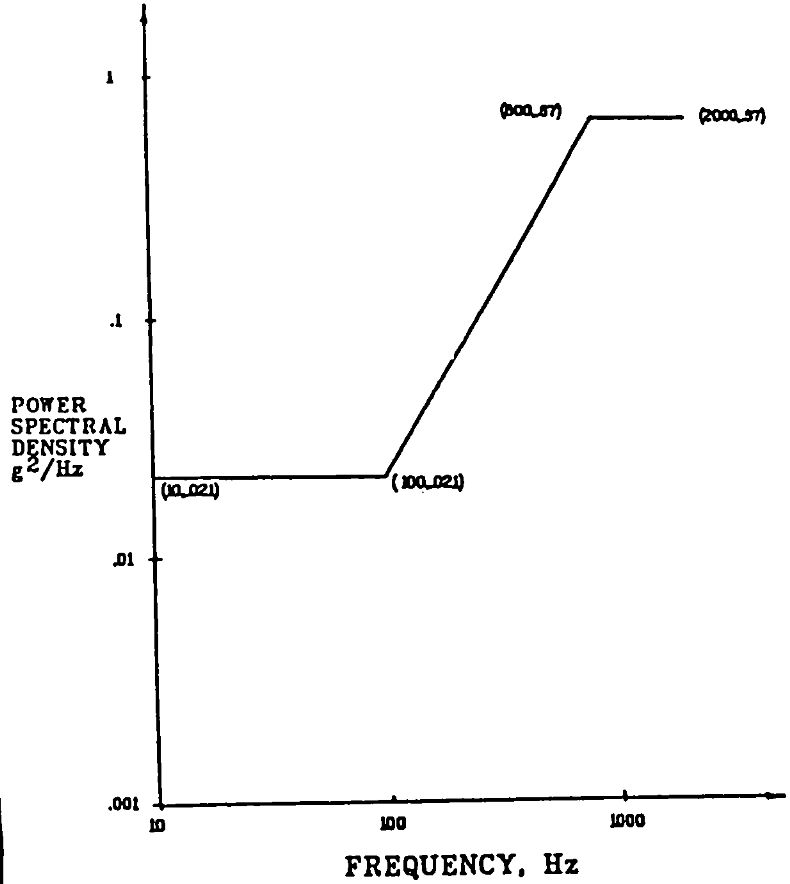
Page:	Drawing:	Suffix:
3 of 11	411447	-01

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments



NOTES:

1. +Y and -Y axes are mutually perpendicular to +X and -X in the lateral axes.
2. Lateral orientation optional as long as it remains mutually perpendicular.



VIBRATION SPECTRUM

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments
ITI										
	030	CHAR: Temperature Cycling SPEC: The connectors shall be subjected, in air, to 19 repetitions of the temperature cycle defined below:	PS411447 9958000	3.2.5		- - -	100%			

TIME, HRS:MIN.	TEMPERATURE
0:00	+22 ± 4°C
0:00 to 1:00	Transition
1:00 to 2:15	-49 ± 6°C
2:15 to 3:15	Transition
3:15 to 4:30	+22 ± 4°C
4:30 to 5:30	Transition
5:30 to 6:45	+86 ± 4°C
6:46 to 7:45	Transition
7:45 to 9:00	+22 ± 4°C

EQPT: 494X435 temperature shock chamber

	040	CHAR: Insulation Resistance 525V ± 25 Volts SPEC: 8000 megohms minimum; or 66 namps maximum EQPT: 494 X 199 (Automatic Tester); 372 X 309 COMT: Test to be performed within 30 days of receipt	PS411447	3.1.1		- - -	100%			
	050	CHAR: Dielectric Withstanding Volts (Apply 1200 ± 60 VDC for 2 seconds minimum. SPEC: No flashover or breakdown EQPT: 494 X 199; 372 X 309	PS411447 MIL-STD-202 Mtd. 301	3.1.2		- - -	100%			
	060	CHAR: Visual SPEC: There shall be no evidence of cracking, breaking, loosening of parts or other damage, which would render the connectors unfit for service. EQPT: Microscope 10X	PS411447	3.2.5		- - -	100%			

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments

If all lot sample connectors pass sequence 040, 050 and 060, the lot sample tests are successful. Continue to sequnece 070, Marking. If any lot sample connector fails sequence 040, 050, or 060 it shall constitute a total lot failure and all connectors shall be held for disposition or return to the Vendor. Notify QCE and Management immediately of failures.

MARKING: ITI - Generate Service Request to have Unit 487 Laser Mark Connectors to Drawing 411447-01. Forward Tagged Connectors and Request to Unit 487 in Area 351, Work Station 980.

UNIT 487

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments
	070	CHAR: Laser Mark Connectors to Meet Drawing 411447-01 per latest OI and Index								

ELECTRICAL: - ITI

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments
	080	CHAR: Insulation Resistance 525V ± 25 Volts SPEC: 8000 Megohms minimum; or 66 namps maximum EQPT: 494 X 199 (Automatic Tester); 372 X 309 COMT: Test to be performed within 30 days of receipt.	PS411447	3.1.1		- - -	100%			

The following test sequence is to be followed when performing IR testing on 372 X 309 tester. Testing may be discontinued as soon as the individual pin resistance meets the 500 namp minimum requirement. NOTE: Retest only the pins that fail.

TESTER	1st TEST	2nd TEST	3rd TEST	4th TEST
372 X 309	2 Seconds	60 Seconds (automatic)	48 Seconds	10 Seconds

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments
	090	CHAR: Dielectric withstanding Volts (Apply 1200 ± 60 VDC for 2 seconds min. SPEC: No flashover or breakdown EQPT: 494 X 199; 372 X 309	PS411447 MIL-STD-202 Method 301	3.2.1	B	.15/--	10/0			
	100	CHAR: Contact Resistance (Apply 100 ± 5mA) SPEC: 20 milliohms maximum EQPT: LCR Bridge and UA6116 with AF394023-000 COMT: Test 3 contacts each of 5 connectors. Identify contacts on FC-57. Selected per random sample table.	PS411447	3.1.4	B	.15/--	5/0			

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments
	110	CHAR: Contact engaging and separating forces @ 5-20 in/min. SPEC: Engagement Force: .5 to 25. oz. Disengagement Force: 1.0 oz. minimum EQPT: MN314203-T2796-2 with Tip MN314203-T2796-3 COMT: Test 37 contacts on a total of 5 connectors.	PS411447	3.1.3	B	.40/-	37/0			
MECHANICAL:										
ASSEMBLY										
	120	CHAR: Contact Location (.070 + .000 - .003 diameter) SPEC: .004 diameter @ MMC EQPT: MN411447-T1 COMT: If part will not enter gage, pin alignment tool SK040583-26B followed by SK040583-26A may be used. Part may then be regaged. Pin alignment tools do not require calibration. Record quantity reworked and notify PCE.			B	.40/-	37/0			
	130	CHAR: Insert arrangement SPEC: Note 16, 411447-01 EQPT: 357823-G1; Inst. AF260624-000			B	.40/-	37/0			
	140	CHAR: Pin Diameter (Back End) SPEC: .069 + .002 - .001 EQPT: MN411447-T3 COMT: 10 Pins each connector			B	.40/-	37/0			
	150	CHAR: Pin Diameter (Back End) SPEC: .040 + .001 - .001 EQPT: MN411447-T3 COMT: 10 Pins each connector			B	.40/-	37/0			
	160	CHAR: Threads (External) SPEC: 1.250-18 UNEF EQPT: Engage locknut over entire length of thread to assure function.			B	.40/-	37/0			

PURCHASE" MATERIAL QUALITY PLAN - Continued FC-9	Page: 7 of 11	Drawing: 411447	Suffix: -01

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	A/C	Rej.	Insp. Test	Inspector Comments

VISUAL: SURFACE MARKS, NICKS AND SCRATCHES OR OTHER SURFACE IMPERFECTIONS NOT AFFECTING FIT OR FUNCTION OF PART ARE ACCEPTABLE.

Shell

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	A/C	Rej.	Insp. Test	Inspector Comments
	170	CHAR: Cracks (affecting sealing) SPEC: None Allowed EQPT: Bench Microscope As Required COMT: Verify by leak check			B	.40/-	37/0			
	180	CHAR: Voids (affecting sealing) SPEC: None Allowed EQPT: Bench Microscope As Required COMT: Verify by leak check			B	.40/-	37/0			
	190	CHAR: Metal burrs, slivers, particles, etc. SPEC: None Allowed EQPT: 2-3X Magnification			B	- - -	100%			
	200	CHAR: Foreign Material in Glass (extending more than 1/2 the distance contact to to contact or contact to ledge) EQPT: 10X Microscope			B	- - -	100%			
	210	CHAR: Surface Contamination SPEC: Minimum Allowed EQPT: Visual			B	- - -	100%			
	220	CHAR: Raised Glass SPEC: There shall be no glass on the relief or undercut area of the pins. EQPT: Microscope			B	- - -	100%			
	230	CHAR: Surface Finish-EMS Area SPEC: 32 microinch EQPT: Visual surface finish comparator			B	- - -	100%			

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspec Comme
ASSEMBLY										
	240	CHAR: Protective Cap SPEC: MS27502-A17A EQPT: Visual			B	----100%				
	250	CHAR: Gasket SPEC: Verify no damage and no particles over .030 in diameter EQPT: Bench Microscope and Reticle (use 30X power with Reticle) or Toolmaker's Microscope COMT: Part may be cleaned with dry Nitrogen			B	.40/-	37/0			
MARKING:										
	260	CHAR: SA Number SPEC: SA3581 EQPT: Visual			B	.40/-	37/0			
	270	CHAR: Suffix of Part Number SPEC: Verify EQPT: Visual			B	.40/-	37/0			
	280	CHAR: Supplier's Trademark SPEC: Verify EQPT: Visual			B	.40/-	37/0			
	290	CHAR: Date Code (Ink Stamp) SPEC: XXXX EQPT: Visual COMT: Optional			B	.40/-	37/0			
	300	CHAR: Serial Number SPEC: Verify EQPT: Visual			B	.40/-	37/0			

PURCHASE MATERIAL QUALITY PLAN - Continued FC-9.4	Page: 9 of 11	Drawing: 411447	Suffix: -000

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments
PHYSICAL:										
	310	CHAR: Helium Leakage SPEC: No Leakage Allowed EQPT: Fixture 46D105683A1-P3 or -P4(Alt.); 372 X 381 Maximum allowed reading is 2000 divisions, meter reading times multiplier (Sample: 40 X 50 = 2000) COMT: Vendor Not Liable for Leakage Less Than 1 X 10^{-6} cc/sec			B	- - -	100%			
MECHANICAL: ITI - QUALIFICATION										
SHELL										
	3200	CHAR: Keyway Location SPEC: .004 wide @ MMC EQPT: 357942-G3; Inst. AF260626-000			D	6.5/47	8/1			
	3300	CHAR: Keyway Width ** SPEC: .126 + .005 - .001 EQPT: 356323-G1 No-Go COMT: Go .001 tolerance check by 357942-G3 Seq. 3200			D	6.5/47	8/1			
	3400	CHAR: Keyway Width (4) ** SPEC: .063 + .005 - .001 EQPT: 356323-G2 No-Go COMT: Go .001 tolerance check by 357942-G3 Seq. 3200			D	6.5/47	8/1			
	3500	CHAR: Inside Diameter (Datum D) SPEC: .937 + .005 - .001 EQPT: 357942-G4 No-Go & Instr. AF260627 COMT: Go .001 tolerance check by 357942-G3 Seq. 3200			D	6.5/47	8/1			
	3600	CHAR: "O" Ring Groove Inside Diameter SPEC: 1.363 ± .005 EQPT: Ring Gage Q/MN315724-T14			D	6.5/47	8/1			

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspecto Comment
	3700	CHAR: "O" Ring Groove Width SPEC: .090 ± .005 EQPT: Vernier or Drill Pins (Go No-Go)			D	6.5/47	8/1			
	3800	CHAR: "O" Ring Groove Depth SPEC: .050 ± .005 EQPT: Bench Comparator with Special Tip COMT: Measure groove depth in approximate center of groove			D	6.5/47	8/1			
	3900	CHAR: Surface Finish "O" Ring Groove (Entire Surface) SPEC: 32 microinch EQPT: Profilometer or Surfanalyzer with deep hole probe			C	- - -	15/0			
	4000	CHAR: Flaws "O" Ring Groove SPEC: Minimum Amount EQPT: 10X Microscope			D	6.5/47	8/1			
	4100	CHAR: Keyway Width SPEC: .063 + .001 - .002 EQPT: Toolmakers microscope			C	- - -	15/0			
	4200	CHAR: Length from front to "O" ring groove ledge SPEC: 1.790" - 1.785" EQPT: Bench Comparator, Vernier or Depth Micrometer			D	6.5/47	8/1			
	4300	CHAR: Backend I.D. SPEC: 1.016 - 1.021 EQPT: Set Inside Calipers Go/No-Go COMT: Recommend setting caliper with Optical Comparator			C	- - -	15/0			
	4400	CHAR: Backend Depth SPEC: To be determined EQPT: Bench Comparator or Depth Micrometer			C	- - -	15/0			
	4500	CHAR: Inside Diameter (Modified Minor) SPEC: 1.016 - 1.021 EQPT: Set Inside Calipers Go/No-Go COMT: Recommend setting caliper with Optical Comparator			C	- - -	15/0			

PURCHASE MATERIAL QUALITY PLAN - Continued FC-9.14

Page:	Drawing:	Suffix:
11 of 11	411447	-01

Lab(Unit)	Seq.	Quality Characteristic / Specification Equipment - (Gage) / Comments	Assoc. Spec.	Spec. Section	CL	AQL/LTPD	N/C	Rej.	Insp. Test	Inspector Comments
	4600	CHAR: Bayonet Pin Location (3) SPEC: .006 Diameter @ MMC EQPT: 357942-G2 Instruction: AF260625-000			D	6.5/47	8/1			
	4700	CHAR: Deck Height to Pins SPEC: .341 + .010 - .010 EQPT: Dial depth indicator COMT: Pins are fragile			C	- - -	15/0			
	4800	CHAR: TP of Anti-Rotational Tab SPEC: .005" at MMC to -A-, -C- at MMC and -D- at MMC EQPT: ~~Optical Comparator~~ Capability Study Room			C	- - -	15/0			
	4900	CHAR: Maximum Radius SPEC: .067 EQPT: ~~Optical Comparator~~ Capability Study Room			C	- - -	15/0			

**THE CONNECTOR MEETS MINIMUM ACCEPTABLE REQUIREMENTS IF ONE SMALL KEYWAY ACCEPTS ITS NO-GO GAGE THE FULL LENGTH AND THE REMAINING SMALL KEYWAYS ACCEPT THE NO-GO GAGE NO MORE THAN APPROXIMATELY ONE-THIRD THE FULL LENGTH.

Drawing	Suffix	Description
411447	-01	CONNECTOR (SA3581)

Issue Date	Rev	QCE	FCO/ER	Change
07/11/89	A	DDR		Initial Issue.
08/16/91	G	LKB		Major re-write to latest revision.
02/28/92	C	LKB		Correct Seq 480 & 490Q and minor Type Os

QCE	PLANNER/PCE	QCE

CHANGE:

COMMENTS:

APPENDIX D

Evaluation Parameters
Proof of Development Build

Subject: MC4196 ENVIRONMENTAL TESTING (Process Development Activity)

Purpose of Endeavor: To complete environmental testing of SRAM II MC4196 LACs at low (-55°C) and high (+85°C) temperatures. All previous environmental testing has been performed at room temperature only. This testing will provide somewhat of a data base to determine the performance of the MC4196 Varistor LAC in SRAM II environments.

Environments: Mechanical shock (-55°C/+94°C), random vibration (-55°C/+85°C) and thermal cycling.

PERFORM ELECTRICAL TESTING ON ALL 16 LACS BEFORE EXPOSURE TO ENVIRONMENTS
Electrical Test Sequence (IR @ 125 V / FRB / DCW @ 100 V / IR @ 125 V)

MECHANICAL SHOCK

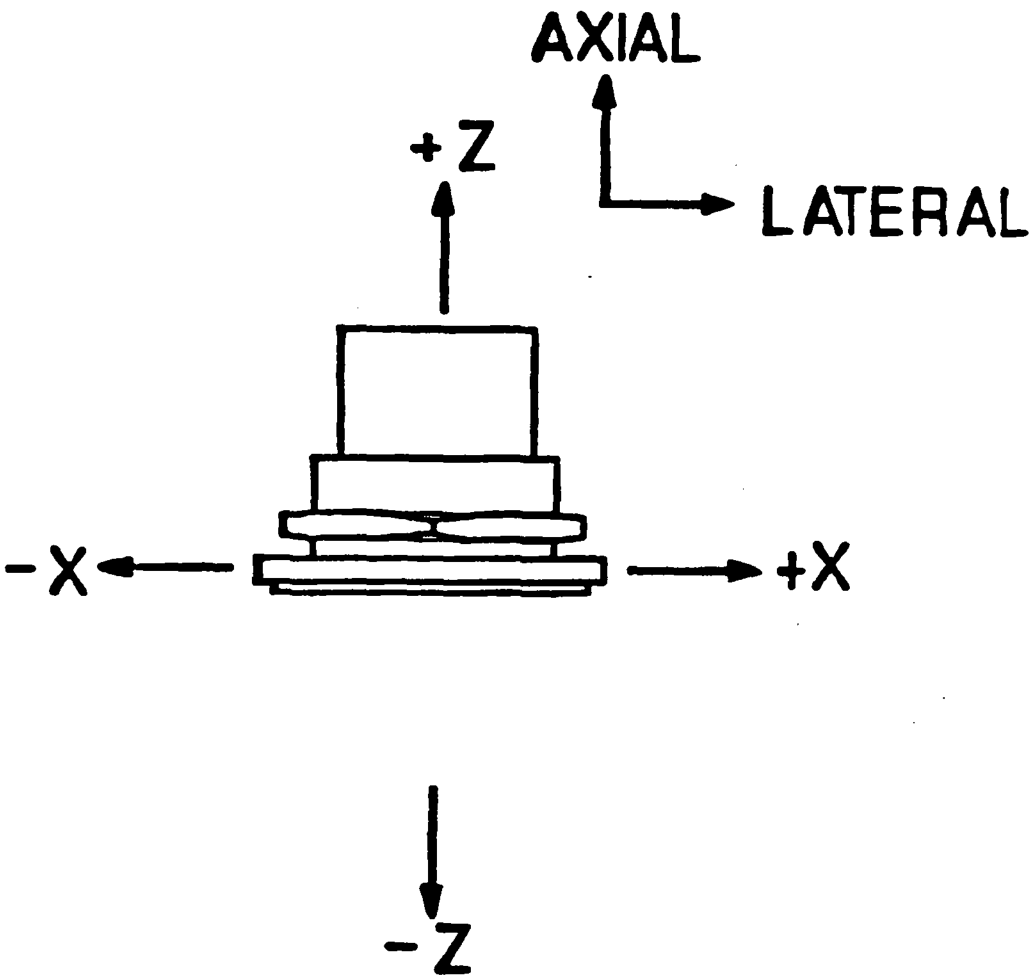
Mechanical shock. The provisions of 9958003 shall apply. Prior to mechanical shock stabilize the LAC at specified temperature for two hours minimum and perform shock test as soon as possible after removal from temperature chamber (test must be performed within 10 minutes of removal from chamber). The LAC shall be mounted in the test fixture and shall be subjected to a shock in the **+X, +Z, and -Z directions** as defined in Figure 1. Shock per Table 1 while stabilized at the specified temperature.

NOTE

AFTER EACH SHOCK, ELECTRICAL TESTS SHALL BE PERFORMED AS FUNCTIONAL CHECKS ON EACH LAC.

Table 1. Mechanical shock

Peak Amplitude	Duration	Approximate Shape	Temperature
375g (± 55g) Electrical Testing	6.0 ms (± 0.90) (IR @ 125 V)	Haversine	-55/+94°C
475g (± 70g) Electrical Testing	6.0 ms (± 0.90) (IR @ 125 V)	Haversine	-55/+94
575g (± 85g) Electrical Testing	6.0 ms (± 0.90) (IR @ 125 V/FRB/IR @ 50 V)	Haversine	-55/+94



NOTES:

1. +Y and -Y axes are mutually perpendicular to +X and -X in the lateral axes.

2. Lateral orientation optional as long as it remains mutually perpendicular.

FIGURE 1

4 MC4196 LACs **Mech. Shock @ -55°C**	4 MC4196 LACs **Mech. Shock @ +94°C**
1) 903-D04-H90	903-D01-H90
2) 903-D07-H90	903-D08-H90
3) 903-D10-H90	903-D17-H90
4) 903-D13-H90	903-D23-H90

RANDOM VIBRATION

Vibration Random. The provisions of 9958004 shall apply. The LAC shall be mounted in the test fixture and subjected to 30 minutes (minimum) of random vibration in the **X and Z directions,** while stabilized at the specified temperature (2 hrs minimum stablization time). **Vibrate per Figures 2 and 3.**

Perform electrical testing (IR @ 125 V/FRB/IR @ 50 V) after completion of vibration defined in Figure 2 (X and Z direction) and again after vibration defined in Figure 3 (X and Z direction).

4 MC4196 LACs **Random Vib @ -55°C**	4 MC4196 LACs **Random Vib @ +85°C**
1) 903-D03-H90	903-D09-H90
2) 903-D05-H90	903-D11-H90
3) 903-D06-H90	903-D12-H90
4) 903-D27-H90	903-D15-H90

TEMPERATURE CYCLING

Temperature Cycling. The MC4196 shall be subjected in air to the temperature cycle defined below.

Time, Hrs:Min	Temperature
0:00	+22 ±4°C
0:00 to 1:00	Transition
1:00 to 2:15	-49 ±6°C
2:15 to 3:15	Transition
3:15 to 4:30	+22 ±4°C
4:30 to 5:30	Transition
5:30 to 6:45	+86 ±4°C
6:45 to 7:45	Transition
7:45 to 9:00	+22 ±4°C

Perform electrical testing (IR @ 125 V) after every eight repetitions of the temperature cycle defined above (8, 16, 24, 32, 40, 48, 56, 64 and 72).

All LACs surviving mechanical shock and random vibration shall be subjected to temperature cycling. ELECTRICAL TESTING WILL BE PERFORMED ONLY ON THE LACs LISTED BELOW AFTER EVERY EIGHT CYCLES. If no LACs survive additional LACs will be provided for temperature cycling.

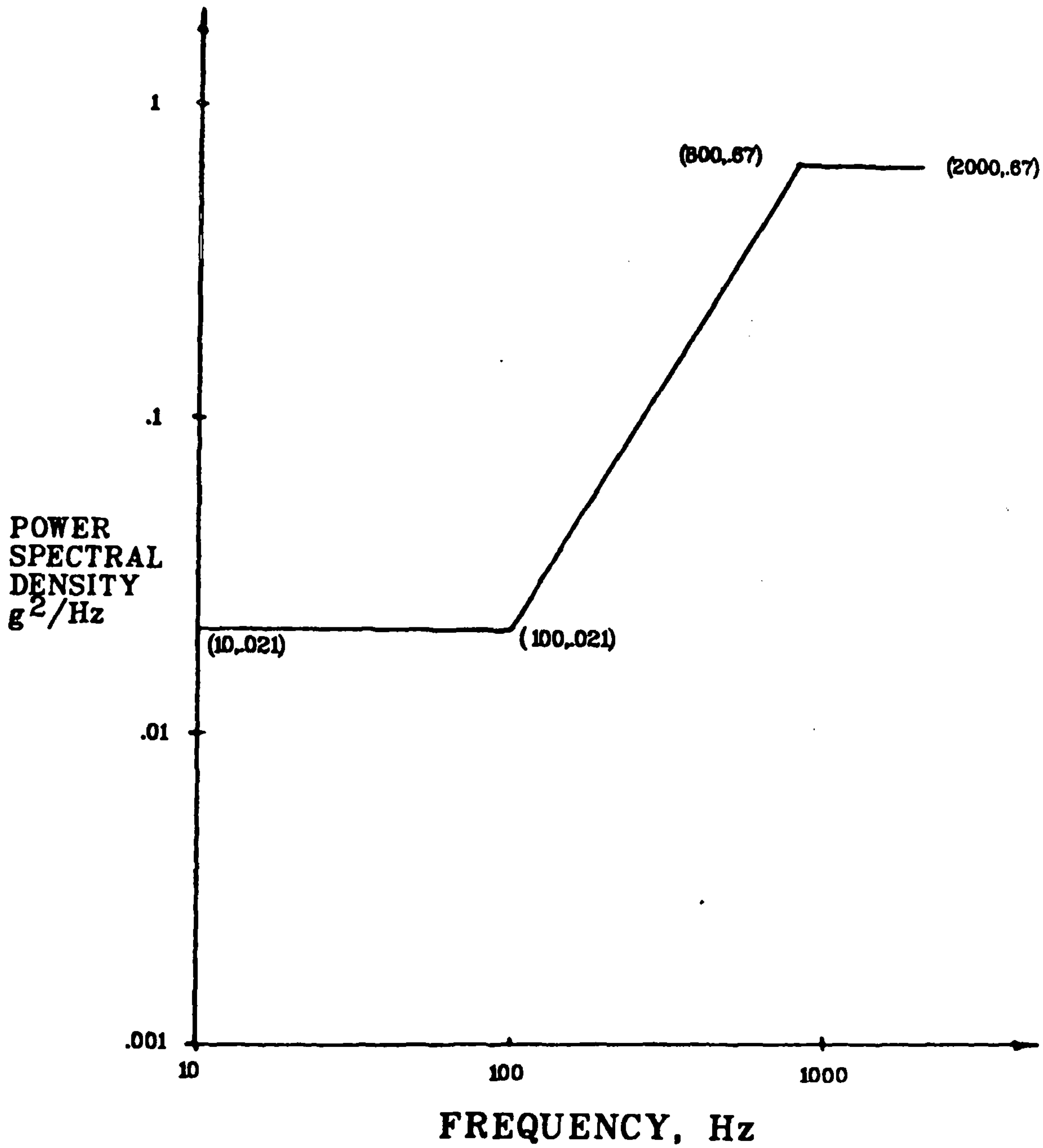


FIGURE 2 - VIBRATION SPECTRUM (See 3.3.2.1)

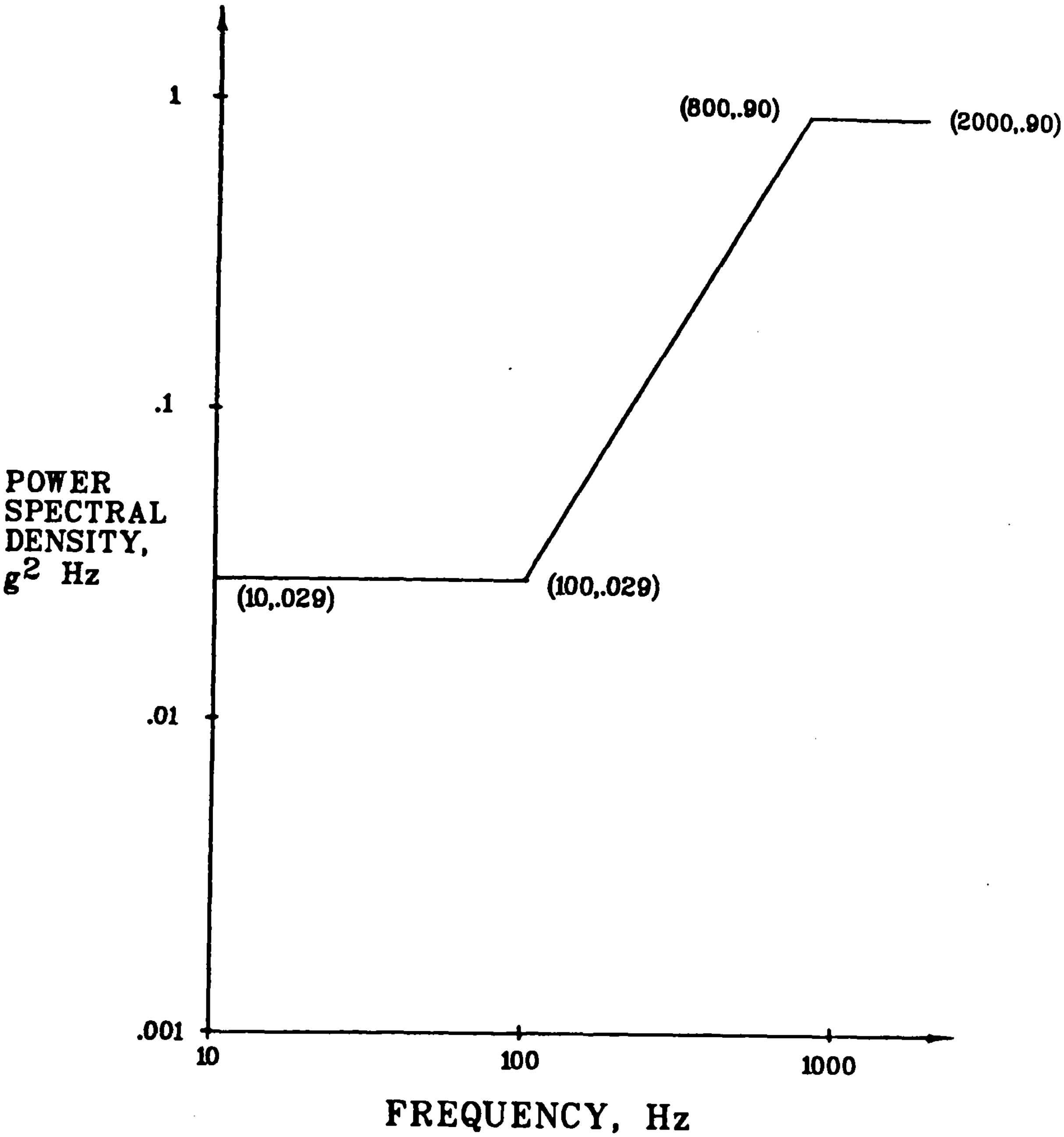


FIGURE 3 - VIBRATION SPECTRUM (See 3.3.2.2)

TEST SAMPLES

903-D04-H90 - Mech. Shock @ -55
903-D10-H90 - Mech. Shock @ -55

903-D08-H90 - Mech. Shock @ +94
903-D23-H90 - Mech. Shock @ +94

903-D03-H90 - Random Vib. @ -55
903-D27-H90 - Random Vib. @ -55

903-D11-H90 - Random Vib. @ +85
903-D15-H90 - Random Vib. @ +85

After temperature cycling perform the following Electrical Tests:

IR @ 125 V/FRB/IR @ 50 V

APPENDIX E

MC4196 Producibility Assessment

PRODUCIBILITY ASSESSMENT SUMMARY

PROGRAM W89 SRAM II

GEND PRODUCT ENGINEER: Greg Gabert

DESIGN AGENCY ENGINEER: Paul Konnick

PRODUCT: MC4196 (LAC)

DATE: 07/10/91

OVERALL RATING: A REVISION: 1 PREVIOUS RATING: B

COMMENTS:

The MC4196 Lightning Arrestor Connector is used on the W89 Sram II Weapon System. The design of the MC4196 includes the SA3581 connector shell which GEND will procure from BCO. The MC4196 will be combined with the SA3642 surge suppressor at BCO and form the MC4078 connector assembly which will be supplied to KCD.

The MC4196 is similar to the MC3592 but will utilize laser welding to replace an internal retainer ring. The varistor material used in the MC4196 will utilize a new chemical preparation. The encapsulant material is more rigid in this design due to the DEA curing agent. The pins in the SA3581 connector are a two-piece design.

The MC4196 will use the PT3290 tester which does not have nine track capability at this time. All tooling, gages and testers shall be identified by drawing and suffix so WR units can utilize the same equipment used for product development. Connectors assembled at this time indicate an 98% yield and further refinements have been identified. The drawing package for the MC4196 has been transferred to GEND. DR and DF drawings have been received. Changes have been completed for the Product Specification, PT3290 test program and tester operating procedures at this time. The PT3290 has been released for Product build.

Based on the above information, the Producibility Assessment overall rating is declared an "A".

PRODUCIBILITY CODES

A. Employs standard NDD capabilities.

B. Requires techniques/equipment new to NDD, but established elsewhere and obtainable. Looks reasonable.

C. Requires development of new techniques. A reasonable approach with the required schedules exists such that a commitment to WR is an acceptable risk.

D. The known techniques/equipment when pressed to the ultimate are marginal at best, and can be expected to give problems in yield/quality/cost control/ and schedule performance. Significant improvement required before committing to WR production.

E. A technique does not exist. One must be developed This category requires a running estimate of the time believed to be needed to develop a technique.

I. Inadequate criteria available to permit assessment

APPROVED: ____________________
Manager, Product Engineering

CLASSIFICATION: UNCLASSIFIED

AUTHORIZATION: ____________________ *DATE:* ____________

UNCLASSIFIED

CLASSIFICATI UNCLASSIFIED
AUTHORIZATION
DATE

PRODUCIBILITY ASSE NT
WORK SHEET

PROGRAM W89 Sram II
PRODUCT MC4196 (LAC)
PRODUCT ENGINEER Greg Gabert
DATE 07/10/91

COMP/ ASM	MAT'L COMPO.	ASM./ PROC.	INSPEC. TEST	EQUIP.	EST. FINAL YIELDS	OTHER	PROJECT TEAM CONCURRENCE: G GABERT, Product Engineer gjg; D EDWARDS, Prod. Engr.; R WHITE, Producibility Engr. RW; E. FIGUEREDO, Program Manager; W. WASHINGTON, Dev. Engr. WW; G. ROUBIK, QA Engr. GR
Connector	A	N/A	A	A	95%		Purchased from Bendix
WEB	A	A	A	A	99%		Manufactured - GEND
Vespel Disc	A	A	A	A	95%		Manufactured - GEND
Teflon Disc	A	A	A	A	95%		Manufactured - GEND
Final Assy	A	A	A	A	99%		Assembled - GEND
Test Reqt	A	A	A	A	97%		Tested - GEND

PRODUCIBILITY CODES

A. Employs standard NDD capabilities

B. Requires techniques/equipment new to NDD, but established elsewhere and obtainable. Looks reasonable.

C. Requires development of new techniques. A reasonable approach compatible with therequired schedules exists such that committment to WR is an acceptable risk.

I. Inadequate criteria available to permit assessment.

D. The known techniques/equipment when pressed to the ultimate are marginal at best, and can be expected to give problems in yield/quality/cost control and schedule performance. Significant improvement required before committing to WR production.

E. A technique does not exist. One must be developed. This category requires a running estimate of the time believed needed to develop the technique.

CLASSIFICATION UNCLASSIFIED
AUTHORIZATION ____________
DATE ____________

PRODUCIBILITY ASSESSMENT
WORK SHEET

PROGRAM W89 Sram II
PRODUCT MC4196 (LAC)
PRODUCT ENGINEER Greg Gabert
DATE 02/10/91

COMP/ ASM	MAT'L COMPO.	ASM./ PROC.	INSPEC. TEST	EQUIP.	EST. FINAL YIELDS	OTHER	PROJECT TEAM CONCURRENCE: G GABERT, Product Engineer; M McKEEL, Sr. Prod. Engr.; R WHITE, QA Engineer; E. FIGUEREDO, Program Manager; W. WASHINGTON, Dev. Engr.
Connector	A	N/A	A	A	95%		Purchased from Bendix
WEB	A	A	A	A	99%		Manufactured - GEND
Vespel Disc	A	A	A	A	95%		Manufactured - GEND
Vespel Disc	A	A	A	A	95%		Manufactured - GEND
Final Assy	A	A	A	A	99%		Assembled - GEND
Test Reqt	A	A	A	A	97%		Tested - GEND

PRODUCIBILITY CODES

A. Employs standard NDD capabilities

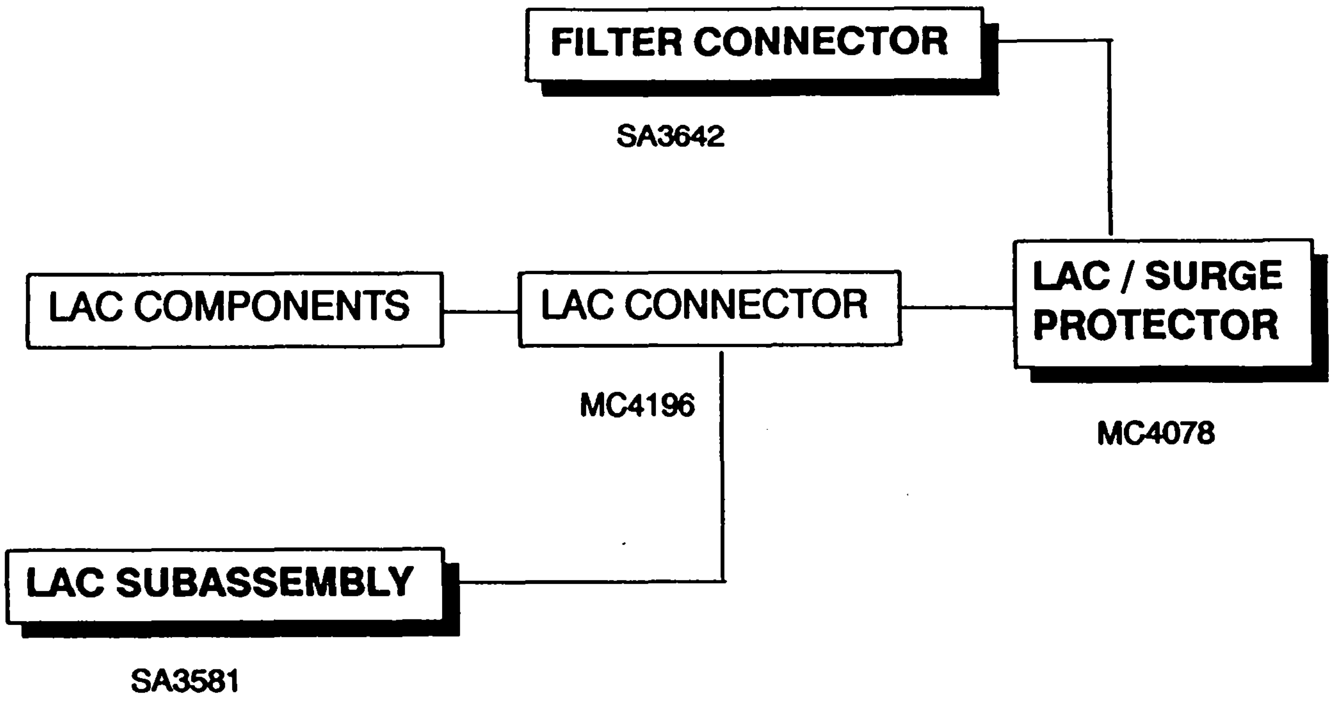
B. Requires techniques/equipment new to NDD, but established elsewhere and obtainable. Looks reasonable.

C. Requires development of new techniques. A reasonable approach compatible with therequired schedules exists such that committment to WR is an acceptable risk.

I. Inadequate criteria available to permit assessment.

D. The known techniques/equipment when pressed to the ultimate are marginal at best, and can be expected to give problems in yield/quality/cost control and schedule performance. Significant improvement required before committing to WR production.

E. A technique does not exist. One must be developed. This category requires a running estimate of the time believed needed to develop the technique.


FILTER CONNECTOR
SA3642
LAC COMPONENTS
LAC CONNECTOR
MC4196
LAC / SURGE PROTECTOR
MC4078
LAC SUBASSEMBLY
SA3581

MC4078 SOURCE DEVELOPMENT PLAN

- DEFINE REASONS FOR ALTERNATE SOURCE DEVELOPMENT
- DEVELOP LIST OF POSSIBLE SUPPLIERS
- ESTABLISH A GRADING SYSTEM FOR SOURCE EVALUATION

REDUCE THE LIST BY CURSORY SURVEY

ISSUE RFQ INCLUDING TECHNICAL PROPOSAL

EVALUATE PROPOSALS- CHOOSE POTENTIAL SUPPLIERS

VISIT POTENTIAL SUPPLIERS

PERFORM FORMAL SURVEY

ORDER AND EVALUATE FIRST DEVELOPMENT HARDWARE

ORDER AND EVALUATE SECOND DEVELOPMENT HARDWARE

CONDUCT QUALIFICATION EVALUATION

LAC CONNECTORS

REASONS TO DEVELOP AN ALTERNATE SOURCE

SUPPLIER ENGINEERING SUPPORT HAS BEEN REDUCED

- CHANGES IN KEY PERSONNEL
- LACK OF TIMELY FEEDBACK
- FOCUS ON HIGHER VOLUME PRODUCTS
- INADEQUATE UP-FRONT PLANNING
- INSUFFICIENT COORDINATION BETWEEN GROUPS

QUALITY PERFORMANCE HAS SUFFERED

- LOW YIELDS
- NOT OPERATING PER PROCEDURES
- LACK OF PROCESS CONTROL & TRAINING
- SCHEDULES HAVE NOT BEEN MET

PRICES HAVE INCREASED

BCO'S FINANCIAL PERFORMANCE HAS SUFFERED

- SALES/PROFIT REDUCTION
- LAYOFFS

WE HAVE NO OTHER DEVELOPED SOURCES

POTENTIAL SUPPLIERS FOR MC4078 LAC

AVIBANK MFG INC.	BURBANK, CA
CINCH	MINNEAPOLIS, MN
CONNECTOR INDUSTRIES OF AMERICA	CINCINNATTI, OH
DEUTSCH CONNECTING DEVICES	BANNING, CA
G&H TECHNOLOGY INC.	CAMARILLO, CA
HERMETIC SEAL CORP.	ROSEMEAD, CA
ITT CANNON	PHOENIX, AZ
JERRIK	PHOENIX, AZ
SABRITEC	IRVINE, CA
SEALTRON	CINCINNATI, OH

MC4078 SOURCE DEVELOPMENT

FACTORS IN JUDGING POTENTIAL SUPPLIERS

QUALITY OF OPERATION

- DEMONSTRATED PERFORMANCE
- PROGRAM FOR CONTINOUS IMPROVEMENT
- DELIVERY HISTORY
- DOCUMENTATION AND RECORDS
- MATERIAL AND LOT CONTROL
- STATISTICAL ANALYSIS CAPABILITY

MANUFACTURING CAPABILITIES

MOLDING	WELDING	TESTING
PLATING	SOLDERING	FUSING
MACHINING	FIXTURING	

COST AND DELIVERY

ENGINEERING SUPPORT

STAYING POWER

MC4078 SOURCE DEVELOPMENT
SANDIA TRAVEL COST

	MO	YR	NO. OF PEOPL	NO. OF SITES	$	FTE FOR TRAVEL ALONE
GRADING SYSTEM REVIEW	12	91	2	1	1000	0.02
EVALUATE PROPOSALS	5	92	2	1	1000	0.02
SUPPLIER DECISIONS	5	92	6	3	9000	0.21
PARTS IN PROGRESS	11	92	3	2	3000	0.07
PARTS COMPLETE	2	93	3	2	3000	0.07
PERFORMANCE REVIEW	6	93	5	1	2500	0.06
PARTS COMPLETE (WELDING SITE)	7	93	4	1	2000	0.05
DESIGN REVIEW	9	93	6	1	3000	0.07
PARTS IN PROGRESS DEV II	3	94	3	2	3000	0.07
PARTS COMPLETE DEV II	9	94	3	2	3000	0.07
PERFORMANCE REVIEW DEV II	12	94	5	1	2500	0.06
PARTS COMPLETE (WELDING SITE)	1	95	4	1	2000	0.05
PRE-QUAL REVIEW	4	95	6	1	3000	0.07
QER	5	96	6	3	9000	0.21
TOTAL					**47000**	**1.08**

COST BASIS $500/PERSON/SITE

LAC SOURCE DEVELOPMENT

STEP	COMPL. DATE	FTE	K$ SERVICES	K$ OUTSIDE REQ'S	K$ TOOLING	K$ TRAVEL	
REDUCE LIST OF SUPPLIERS	OCT '91						
DEVELOP GRADING SYSTEM	DEC '91					1	
PREPARE AND ISSUE RFQ	FEB '92	0.2					
EVALUATE PROPOSALS	MAY '92	0.3				1	1992
ORDERS PLACED	JUN '92				30	9	K$
1992 SUBTOTAL		0.5	0	0	30	11	116
RECEIVE PARTS	MAR '93	0.3		50	20	6	
EVALUATE PERFORMANCE	JUN '93	0.1	20			2.5	
WELD INTO FINAL ASSY	JUL '93	0.1		30	15	2	
EVALUATE FINAL ASSY	SEP '93	0.1	20				1993
DESIGN IMPROVEMENTS	OCT '93	0.1				3	K$
1993 SUBTOTAL		0.7	40	80	35	13.5	274
ORDERS PLACED (DEV II BUILD)	DEC '93						1994
RECEIVE PARTS	SEP '94	0.3		50	10	6	K$
1994 SUBTOTAL		0.3	0	50	10	6	111
EVALUATE PERFORMANCE	DEC '94	0.1	20			2.5	
WELD INTO FINAL ASSY	JAN '95	0.1		30	5	2	
EVALUATE FINAL ASSY	MAR '95	0.1	20				1995
AUTH. QUAL BUILD	APR '95					3	K$
1995 SUBTOTAL		0.3	40	30	5	7.5	127.5
PPI LOT (25 PCS	AUG '96			75			1996
PP/TMS LOT (25 PCS)	NOV '96	0.4	5	125		9	K$
1996 SUBTOTAL		0.4	5	200	0	9	274
PROGRAM TOTAL	5.0 YEARS	2.2	85	360	80	47	902

FTE FOR SANDIA ONLY

TEST EQUIPMENT NOT INCLUDED

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